STRUCTURAL ALUMINUM

ALCOA

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HANDBOOK

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TOPICAL INDEX

FOREWORD

The diversity of form and service which characterizes aluminum alloy structures emphasizes the need for a new method of approach to design problems. This second edition of the Structural Aluminum Handbook presents, for the first time, fundamental information regarding the ultimate strength of structural members fabricated from aluminum alloys. These data, presented by means of discussion, examples, and tables, are based on laboratory investigation, field tests, and extensive practical experience.

Since the publication of the first edition of the book, considerable progress has been made in the manufacture of aluminum alloy structural products and in the design and fabrication of structures employing these products. This progress is reflected in the increased scope of this second edition.

The section on characteristics, manufacture, and fabrication has been enlarged and brought up to date, and a section containing commercial sizes, tolerances, and specifications has been added. The tables of elements of sections for structural shapes have been expanded and values for torsional constants, together with notations on the present availability of sections, have been added. Elements of sections for rectangular shapes and for tubes have been included and arranged to facilitate computation.

The calculations involved in the preparation of this book are based upon the theoretical cross sections as shown in the tables. It should be noted, however, that in practice these sections vary according to the commercial tolerances shown in the tables.

While Aluminum Company of America does not assume responsibility for customers' designs nor for the performance of structures or parts made in accordance therewith, its engineering-sales service is always available for the purpose of discussing the application of aluminum products to customers' designs: the use of special purpose alloys, metallurgical questions, chemical considerations, fabrication technique; in short, the adaptability of these structural alloys and products to customers' needs. A cordial invitation is extended to the users of its products to avail themselves of this service and to visit its general offices and the Aluminum Research Laboratories at any time.

Aluminum Company of America, in common with suppliers of other materials, assumes responsibility for the quality of its product. This responsibility is set forth in detail in the Company's formal warranty clause which appears on all acknowledgments of its orders and which is quoted in full on page 193 of this book.

CHARACTERISTICS, MANUFACTURE, AND FABRICATION OF ALUMINUM ALLOY STRUCTURAL PRODUCTS

PHYSICAL AND MECHANICAL PROPERTIES OF ALUMINUM ALLOY STRUCTURAL PRODUCTS

Aluminum alloys are used in structures chiefly because they combine light weight with strength. This combination permits the building of lightweight structures from members possessing the advantages inherent in generous dimensions and bulk. Furthermore, any well-equipped shop can fabricate aluminum alloy structures with no major change of method or equipment.

Structural members and materials are available commercially in a variety of aluminum alloys and in forms adapted to a wide range of use. The alloys commonly used for different structural commodities are given in Table 1, page 21.

From the mining of the ore to final inspection, each step in the manufacture of Alcoa Aluminum Alloy products is under accurate control. This, combined with rigid testing routine for all products, insures uniform quality of the materials produced by Aluminum Company of America. The production, metallurgy, fabrication, and testing of Alcoa Aluminum and its alloys is covered in detail in the literature listed on page 194.

WROUGHT ALLOYS

Nomenclature and Products

The wrought alloys of Alcoa Aluminum are produced by rolling, extruding, drawing, or forging. They are designated by the letter "S" following a number which identifies the chemical composition, e.g., 3S and 17S.

In one group of alloys, hardness and strength are produced by definite amounts of cold work after the final anneal. In these—the unheat-treatable alloys—fully annealed material is designated by "O," while fully hardened material is designated by "H," e.g., 52S-O and 52S-H. Intermediate degrees of hardness are denoted by fractions, e.g., 52S-¼H and 52S-¾H. The unheat-treatable alloys combine moderate strength with good workability. Their principal structural uses are in the form of sheet, plate, extrusions, and tubing.

In a second group of alloys, final hardness and strength are produced primarily by heat treatment. Maximum physical properties are obtained by a solution heat treatment followed by aging. The annealed condition of the alloy is designated by "O" and the fully

heat-treated and aged condition by "T," e.g., 17S-O and 17S-T. In the case of 17S, aging occurs spontaneously at room temperatures, but aging at elevated temperatures is necessary for 14S, A51S, 53S, and 27S*. The intermediate temper of these alloys, after the solution heat treatment and before aging, is designated by "W," e.g., 53S-W. The heat-treatable Alcoa Aluminum Alloys have high strength and limited workability in the fully heat-treated condition. All forms of structural material including sheet, plate, bar, rod, shapes, tubing, forgings, bolts, and rivets are manufactured from heat-treatable alloys. See Table 1, page 21, for the alloys which are used commercially for the several commodities.

Nominal Compositions

The nominal compositions of wrought Alcoa Aluminum Alloys used for structural purposes are given in Table 2, page 22. The maximum amount of alloying element added in any of these is about 6 to 7 per cent.

Mechanical Properties

Commercially pure aluminum weighs 0.098 pound per cubic inch and, fully annealed, has a yield strength of about 4000 pounds per square inch. The weight of the wrought alloys used for structural purposes varies from 0.096 pound per cubic inch to 0.101 pound per cubic inch. By means of alloying and heat treatment, the yield strength can be increased to 50,000 pounds per square inch. Based on commercially pure aluminum, the variation in weight of the different alloys is less than 4 per cent, while the increase in yield strength may be more than 1000 per cent. In some of the alloys the specific gravity is less than that of commercially pure aluminum. The typical mechanical properties of the Alcoa Aluminum Alloys used for structural purposes are tabulated on page 23.

Tensile strengths, yield strengths, and elongations of structural Alcoa Aluminum Alloys at elevated temperatures are given in Table 7, page 27. These data provide some measure of the ability of the various alloys to withstand prolonged exposure at elevated temperatures. For specific information concerning the suitability of the various alloys for use at elevated temperatures, the nearest sales office of the Aluminum Company of America should be consulted.

*Special purpose alloy. See page 19.

Modulus of Elasticity

The modulus of elasticity of all aluminum alloys is approximately 10,300,000 pounds per square inch. This factor is important in studies of structural stability as well as in the design of compression members and beams. Deflection under load is dependent on both the form and arrangement of members as well as on the modulus of elasticity of the material. Desired stiffness can be provided by choosing a suitable form of member and by correct distribution of metal. A low modulus of elasticity tends to cushion the shock of impact and decreases the magnitude of stresses set up by misalignment of structural members.

Repeated Stress

The resistance of metals to repeated stress is ordinarily measured by a value known as endurance limit. Endurance limit is the highest stress at which the metal will withstand an indefinitely large number of complete reversals of stress, tension to compression. This endurance limit has little significance in structural design, because loading conditions which produce complete reversal of maximum stress seldom occur in structures. It is sometimes desirable to investigate the possibility of fatigue action at some lower number of cycles than that indicated by the endurance limit. Table 5, page 25, presents data obtained on specimens tested in the R. R. Moore rotating-beam fatigue machine in which only the extreme fiber is subjected to the maximum stress in each cycle. The approximate maximum stresses which the materials will withstand are given for various numbers of cycles. The values in the last column of this table, corresponding to 500,000,000 cycles of completely reversed stress, are the endurance limits for the various Alcoa Aluminum Alloys.

The data in Table 6, page 26, were obtained on a direct tension-compression testing machine in which a much wider range of stress variation is produced than is possible in the rotating-beam type of machine. On the direct tension-compression testing machine, the entire specimen is subjected to the maximum stress in each cycle. This difference in stress distribution is responsible for the fact that, for comparable tests in complete reversal, the direct tension-compression results are always somewhat lower than those obtained by the rotating-beam test.

Thermal Expansion

The coefficient of thermal expansion of the wrought aluminum alloys used for structural purposes varies from 0.0000114 to 0.0000128 inch per inch per degree Fahrenheit. Thermal expansion must be considered in relation to the behavior of large structures and in the measurement of long structural members. Table 8, page 28, gives the change in length of wrought Alcoa Aluminum Alloys corresponding to changes in temperature. In aluminum structures, secondary stresses resulting from temperature changes are less than those in similar steel structures, because the lower modulus of elasticity of aluminum compensates for its greater coefficient of thermal expansion.

Electrical and Thermal Conductivity

The electrical and thermal conductivities of aluminum alloys vary with alloy, heat treatment, and amount of strain hardening. The high thermal conductivity of aluminum alloys makes it possible to use hot-driven rivets in heat-treated aluminum alloys without damage to mechanical properties.

Resistance to Corrosion

Aluminum alloys used for structural purposes have good resistance to atmospheric corrosion. This decreases the cost of maintenance and increases the safety of structures made of them. Corrosion may occur under severe conditions; therefore, aluminum structures, like those made of other materials, should have adequate paint protection. This is particularly true for structures which may be subjected to the corrosive agents that occur in mine waters or in certain industrial processes.

MANUFACTURE OF WROUGHT ALLOY COMMODITIES

The methods of manufacturing Alcoa Aluminum Alloy structural materials vary with the commodity and alloy. Maximum commercial sizes for the various commodities are given on pages 174 to 181, and commercial tolerances are shown on pages 167 to 173.

Rolling

Sheet, plate, shapes, rod, and bar are produced by rolling. Thick plate and shapes are flattened and straightened by rolls, while sheet and certain sizes of plate and shapes are straightened by stretching.

Extruding

Extruded shapes are produced by forcing metal through an orifice having the shape of the desired cross section. The member is then straightened by stretching. There are definite limitations to the weight per foot of length and to the total weight per piece of extruded sections. In general, sections which may be enclosed in an 11-inch circle can be extruded. Larger sections are sometimes produced, but, where these are desired, the nearest sales office of Aluminum Company of America should be consulted. Tools required for producing extruded shapes are relatively inexpensive.

Many of the 17,000 extruded sections now produced are useful in supplementing standard structural shapes. Maximum economy of metal and fabricating cost can often be effected by designing members especially adapted to a given purpose, and it is for such that extruded shapes are generally used.

Drawing

Seamless tubing is produced in a variety of alloys and sizes. The commercial range of diameters and wall thicknesses of round tubing is given in the table on pages 179 and 180. Oval, square, rectangular, streamline, and special shapes are also available.

Forging

Die and open forgings are made from several aluminum alloys. Forging develops excellent properties in these alloys, and such forgings represent the maximum in combined strength and light weight. Open forgings weighing over 1300 pounds have been made, and intricate shapes are produced in smaller die forgings.

*Heat Treating**

The solution heat treatment of wrought alloys consists of heating at carefully controlled temperatures, varying from 930°F. to 980°F. for different alloys, and quenching. The time of heating depends on the size of load in the furnace and the thickness of the material. The sudden change in temperature, caused by the quench, may result in some distortion of the piece. This distortion is removed by subsequent rolling or stretching operations, but it must be given careful consideration where solution heat treatment is contemplated on a pre-formed member. The solution heat treatment is followed

*Many of the heat-treating processes applicable to Alcoa Aluminum Alloys are patented.

by an aging or precipitation heat treatment at room temperature for 17S and at temperatures around 300°F. for alloys 53S, 27S*, and 14S. This aging treatment seldom produces severe deformations of the material.

FABRICATION OF ALUMINUM ALLOY STRUCTURES

Forming

Through proper choice of alloy, bend radii, and tools, a great variety of forming operations can be performed on aluminum alloys. Ordinary types of presses, brakes, or rolls are suitable for this work, but it is highly desirable that the surfaces of the tools which come in contact with the aluminum alloys be smooth and free from tool marks, dents, or rough edges which would tend to tear or score the metal. For difficult operations, lubricants, such as heavy oils or tallow mixed with a small amount of mineral oil, can be used to advantage.

The surface and edges of the metal to be bent should be smooth. Scratches, nicks, and sharp corners should be removed. A pencil or crayon, rather than a punch or scriber, should be used for marking bend lines.

Shape of section and thickness of metal determine the severity of forming which can be accomplished successfully for a given alloy and temper. Table 9, page 29, indicates the cold bend radii which are commonly used for various Alcoa Alloys and thicknesses of sheet or plate. These values have been established by tests and practical experience, but it is advisable to try out the operation with available tools on sample pieces where a minimum bend radius is necessary.

For cold forming, the severity of the operation, which can be accomplished successfully, decreases as the hardness or strength of an alloy increases. With the alloys which derive their strength from cold working, the proper alloy and degree of hardness can be selected to assure the success of a given forming operation. For heat-treated alloys, forming can be done either hot or cold on annealed material, and strength developed by subsequent heat treatment. In alloys which are artificially aged, such as 53S, material in the "as quenched" or "W" temper is much more ductile than the fully heat-treated and aged or "T" material. Cold forming can be done

*Special purpose alloy. See page 19.

in the intermediate temper and the member subsequently aged to develop full strength.

Excessive heating of heat-treated material affects temper and reduces strength. At 400°F. the workability of 53S-T and 27S-T* is much better than at room temperatures and, providing this temperature is maintained for not more than a few minutes, there is no harmful effect on the properties of the metal. The use of this method of forming 17S-T is undesirable as the resistance to corrosion may be impaired. Where forming at 400°F. is attempted, it is important that a frequent check of metal temperature be made with an accurate contact pyrometer.

3

Machining

Machining operations can be performed, using the same methods and equipment as with steel, but for best results cutting tools must be specially ground. Tools should have keen edges with more side and top rake than is usual for steel. In all machining operations, a liberal use of a cutting compound is desirable. For detailed discussion, the booklet, "Machining Aluminum," should be consulted.

Shearing

Aluminum alloy sheet, plate, and shapes ½ inch or less in thickness can be sheared on any of the types of equipment used for steel. Blades should be sharp and clearances adjusted to give smooth cuts. Material thicker than ½ inch should be sawed.

Sawing

Straight, curved, and coping cuts can be made by saws. Lubricants of the soluble oil type are recommended. For straight cuts, stationary or portable circular saws are used, while band saws are used for curved or coping cuts. In any type of work, high blade speeds are desirable. A speed of 5000 feet per minute is recommended for band saws, while a peripheral speed of 10,000 feet per minute gives good results with circular saws. The saw teeth should be fairly coarse with a slight set and a slight amount of front rake.

Punching, Reaming, Drilling

Rivet or bolt holes in primary-load-carrying members should be drilled or subpunched and reamed. On material over ½-inch thick, all holes should be drilled. Both single and multiple type punches such as are used on structural steel are suitable for aluminum alloys.

*Special purpose alloy. See page 19.

The punch should be accurately centered in the die with a radial clearance of about $\frac{1}{32}$ inch. Cutting edges of both punches and dies should be sharp. In punching tread plate, the punch should enter from the pattern surface of the plate. For rivets of $\frac{5}{8}$-inch diameter or larger, holes should be subpunched $\frac{1}{8}$ inch less than the nominal diameter of the rivet and reamed to finished size of not more than $\frac{1}{32}$ inch greater diameter than the nominal rivet size.

Reamers should be of the high-speed, spiral-fluted type. Reaming operations on aluminum alloys are about twice as fast as the same work in steel.

Twist drills used on aluminum alloys should be kept sharp and constantly lubricated with a soluble oil. Drill speeds can be increased about 50 per cent above those used for steel. Special drills with more than the normal number of twists per inch can be used to advantage where a large amount of work is to be done. A double-fluted twist drill with a spiral angle of 47° gives good results on aluminum alloys.

Riveting

Both aluminum alloy and steel rivets are used in the fabrication of aluminum alloy structures. Information on the dimensions and strength of aluminum alloy rivets is given on pages 66 and 151. In any riveting operation, it is desirable that the clearance of the rivet in the hole be held to a minimum.

Aluminum alloy rivets should be used in structures where high resistance to corrosion or uniform appearance, with the elimination of possible rust stains, is desired.

Squeeze-type riveters should be used on aluminum rivets where possible. Pneumatic hammers and back-up tools should be heavier than those used for steel rivets of the same size. The flat cone type of driven head shown on page 151 facilitates driving and has a good appearance.

Rivets of 17S alloy are driven either hot or cold. For hot driving, the rivets are heated in a bath of molten lead, sodium nitrate, or by other suitably controlled means. The rivets must be brought up to temperatures of 930°F. to 950°F., and held there from 15 minutes to 30 minutes. Positive and accurate temperature control is essential. Rivets are transferred from the heater to the work and driven in the least possible time. A quench is obtained by contact with the cold metal and tools. If this method is carried out correctly,

the 17S rivets will develop 17S-T properties after aging at room temperature. Rivets of 17S alloy in the smaller sizes can be driven cold if the heating is followed by quenching in cold water and the rivets are driven immediately after quenching. Such rivets attain 17S-T properties after aging at room temperature.

Rivets of 53S alloy can be driven either hot or cold. For hot driving, the procedure is the same as that for 17S except that the temperature of the rivets should be 960°F. to 980°F. Rivets of 53S are supplied in the "W" temper for cold driving. Alloy 53S-W ages very slowly, but, if kept in a warm place or at normal room temperature for several months, 53S-W rivets age sufficiently to decrease ease of driving.

Standard steel fabricating practice is followed in driving hot steel rivets in aluminum alloy structures. Annealed steel rivets are driven cold in sizes up to 1-inch diameter. Flat or cone-type heads are used, and results are satisfactory in quality and economy. For cold-driven steel rivets over ½ inch in diameter, the squeeze-type riveter must be used.

Experience with many riveting operations, on all types of structures of heat-treated aluminum alloys, has proved that distortion is no greater than in steel structures. When riveting the softer grades of aluminum, special care must be exercised to avoid over-driving. The driven head should, where possible, be formed on the side of the work having the greater thickness or hardness of metal. For the details of riveting operations on aluminum alloys, the booklet, "Riveting Aluminum," should be consulted.

Welding

Certain alloys of aluminum may be welded by torch, electric arc, spot, and seam methods. Welding tends to decrease the strength of heat-treated material because of the annealing effect. In some cases satisfactory results can be obtained by the heat treatment of parts after welding. Welding processes for aluminum alloys are being developed rapidly. The booklet, "The Welding of Aluminum," gives much valuable information on this subject.

Burning

Flame-cutting should not be attempted with aluminum alloys. The excessive heat damages the metal and the cut edge is very ragged. The metal melts instead of burns.

Painting

Although aluminum and its alloys do not rust, it is frequently desirable under severe conditions of exposure to protect them with paint as in the case of other metals, especially where thin sections are employed. For ordinary conditions of use such as bridge floors, flood bulkheads, and excavator booms, the finishing system used on steel structures may generally be employed with some changes in the surface preparation and priming coat.

It is important that surfaces be properly prepared before painting. One satisfactory method is to treat the surface with a solution of phosphoric acid combined with special grease solvents. A number of such mixtures for chemical treatment are commercially available. In using treatments of this type the manufacturer's directions should be followed and the surface thoroughly rinsed with clean water after treating in the solution. For many conditions of use it may be found unnecessary to employ any special surface preparation other than to remove accumulations of grease or dirt by means of washing with a solvent.

As a priming coat, a paint containing a substantial proportion of zinc chromate has been found to be most effective. Where possible, the pigment portion of the primer should consist substantially of zinc chromate with a small amount of inert pigment. For the finishing coat, aluminum paint is the most durable, but where other colors are desired, any durable finishing paint may be employed.

Paint coatings may be applied to aluminum surfaces by employing practically the same procedure and equipment as in the case of steel or other metallic surface. For a more complete discussion of the use of paints on aluminum, the booklet "Finishes for Aluminum" should be consulted.

CASTING ALLOYS

Aluminum alloy castings are suitable for many structural applications. In certain cast alloys, the mechanical characteristics are obtained by alloying alone and the material is designated by the term "as cast." In other alloys, the properties are improved by heat treatment. The chemical composition of casting alloys of Alcoa Aluminum is designated by a number, while the heat treatment is designated by the letter "T" followed by a number, e.g., 220-T4. The nominal compositions of several casting alloys most suitable for structural uses are given in Table 2, page 22.

Mechanical Properties

Typical mechanical properties of certain sand-cast alloys of Alcoa Aluminum are shown in Table 4, page 24. These values have been determined from standard ½-inch diameter test specimens individually cast in green sand molds and tested without machining off the surface. Such samples serve as a control of metal quality and heat treatment. As is the case with other metals, the mechanical properties of such test samples do not necessarily represent the properties of test bars cut from commercial castings. They may be higher or lower, depending on such factors as thickness, gating, risering, chilling, pouring temperature, and on the permeability and moisture content of the sand. The load which a given casting will carry depends on form and foundry practice as well as on the mechanical properties shown by test bars. In the design of castings the services of the engineering and technical staff of Aluminum Company of America are available on request.

For structural purposes, most aluminum alloy castings are made in sand molds produced from wood patterns. Patterns which have been used for other metals can often be modified for the production of aluminum alloy castings, but in some cases it is desirable that special patterns be made because of differences in shrinkage and in foundry methods. Single castings weighing over 3500 pounds have been produced in aluminum alloys.

The booklet dealing with aluminum casting alloys contains much information which will prove useful to the engineer.

SELECTION OF ALLOY

The selection of the proper alloy for a specific structural application depends on the requirements of strength, durability, and economy, and is limited by proposed fabricating methods and by the availability of the commodities required. Table 1 on page 21 is presented to assist the engineer in making a preliminary selection of alloy. Stocks of a limited range of sizes and commodities in certain alloys are available for immediate shipment. Other material within the commercial range of sizes and alloys will be fabricated to order. Stocks are varied to suit the current demand. Before specifying definite aluminum alloy materials for a structure the engineer should consult the nearest sales office of Aluminum Company of America concerning availability and price. This is particularly important in the case of special purpose alloys.

TABLES OF CHARACTERISTICS, COMPOSITION, AND MECHANICAL PROPERTIES OF ALUMINUM ALLOYS USED FOR STRUCTURAL PURPOSES

Definitions, Significance of Terms used in Tables of Mechanical Properties. General Data.

1. For all Alcoa Alloys, wrought and cast, the following approximate values apply:
   - (a) Young's modulus of elasticity . . 10,300,000 pounds per square inch
   - (b) Modulus of rigidity . . . . 3,800,000 pounds per square inch
   - (c) Poisson's ratio 0.33
   - (d) Bearing strength is equal to 1.8 times the tensile strength provided the edge distance, in the direction of stressing, is not less than twice the diameter of the hole.
2. Yield strength is the stress which produces a permanent set of 0.2 per cent of the initial gage length (American Society for Testing Materials Standard Methods of Tension Testing of Metallic Materials—E8-36).
3. Shearing strengths are single-shear values obtained from double-shear tests.
4. Endurance limits are based on withstanding 500,000,000 cycles of completely reversed stress, using the R. R. Moore type of machine and specimen.
5. Elongation varies with the form and size of test specimen. When round specimens are used the gage length for the measurement of elongation is equal to four times the diameter of the reduced section of the specimen.
6. Dimensions given in tables for the following products are as listed below:

   Sheet and plate . . . . . . Thickness

   Tubing . . . . Outside diameter

   Forgings . . . . Diameter or thickness

   Rod and bar . . . . Diameter or least distance between parallel surfaces, or where so stated maximum area of cross section. Maximum size of hexagon is 2 inches; of octagon, $1\frac{3}{16}$ inches; of square, 4 inches.

TABLE 1—CHARACTERISTICS OF ALUMINUM ALLOYS USED FOR STRUCTURAL PURPOSES

Alloy	Usual commercial temper[1]	Standard commodities	Outstanding characteristics	Typical uses
3S	O to H	Sheet, plate, rod, bar, extrusions, tubing, and rivets.	Workability, weldability[2], and resistance to corrosion.	Sheet metal work, decorative trim, and tank plate.
4S	O to H	Sheet and plate.	Higher strength than 3S and resistance to corrosion.	Sheet metal work where intermediate strength is desirable.
52S	O to H	Sheet, plate, rod, and bar.	Highest strength of unheat-treatable alloys, workability, and resistance to corrosion.	Sheet metal work where good strength is desirable, marine and transportation applications.
53S	W and T	Sheet, plate, rod, bar, rolled shapes, extrusions, tubing, rivets, and forgings.	Good strength, best cold workability of heat-treated alloys, weldability[2], and resistance to corrosion.	Structures subject to severe corrosive conditions, naval, architectural, and industrial applications.
17S	T	Sheet, plate, rod, bar, rolled shapes, extrusions, tubing, rivets, bolts, and forgings.	Excellent mechanical properties.	General structural applications, construction, and transportation equipment.
27S[3]	T	Plate, rod, bar, rolled shapes, extrusions, tubing, and forgings.	High yield strength and hardness.	Heavy-duty structures, bridges, hydraulic bulkheads, mine equipment, and power shovel dippers.
A51S	T	Forgings.	High strength with excellent forgeability.	Intricate forgings, machine and automotive parts, and bus body members.
14S	T	Forgings.	Highest strength and hardness of all aluminum alloys.	Heavy-duty forgings and power shovel bails.
43	As cast	Castings.	Weldability and resistance to corrosion.	Architectural trim, sewage disposal plants, and pipe fittings.
214	As cast	Castings.	Good strength and resistance to corrosion.	Machine parts and pipe fittings.
195	T-4, T-6, and T-62	Castings.	High strength.	Machine bases and parts, shop crane trucks, and trolley parts.
356	T-4, T-6, and T-51	Castings.	Weldability[2], pressure tightness, and resistance to corrosion.	Pressure-tight castings.
220	T-4	Castings.	Highest strength and shock resistance of casting alloys.	Heavy-duty castings, power shovel dipper parts, and marine applications.

[1]Available temper varies with commodity and size. See Tables 35 to 54.
[2]Welding tends to anneal tempered material. See page 17.
[3]Special purpose alloy. See page 19.

4

TABLE 2—NOMINAL COMPOSITION OF ALUMINUM ALLOYS USED FOR STRUCTURAL PURPOSES[1]

	Alloy	Per cent of alloying elements. Aluminum and normal impurities constitute remainder				
		Copper	Silicon	Manganese	Magnesium	Chromium
Wrought	3S	...	...	1.2	...	....
	4S	...	...	1.2	1.0	....
	14S	4.4	0.8	0.8	0.4	....
	17S	4.0	...	0.5	0.5	....
	27S[2]	4.5	0.8	0.8	...	....
	A51S	...	1.0	...	0.6	0.25
	52S	...	...	...	2.5	0.25
	53S	...	0.7	...	1.3	0.25
Cast	43	...	5.0	...	...	....
	195	4.0	...	...	...	....
	214	...	...	...	3.8	....
	220	...	...	...	10.0	....
	356	...	7.0	...	0.3	....

[1]Heat-treatment symbols have been omitted since composition does not vary for different heat-treatment practices.

[2]Special purpose alloy. See page 19.

TABLE 3—TYPICAL[1] MECHANICAL PROPERTIES OF WROUGHT ALUMINUM ALLOYS[2]

Alloy	Tension			Compression	Hardness	Shear		Fatigue	Weight
	Yield Strength (Set=0.2%) Lb./sq. in.	Ultimate Strength Lb./sq. in.	Elongation Per Cent in 2 inches. Round Specimen (½ inch diameter)	Yield Strength (Set=0.2%) Lb./sq. in.	Brinell 500 kg., 10 mm. ball	Yield Strength (Set=0.2%) Lb./sq. in.	Ultimate Strength Lb./sq. in.	Endurance Limit Lb./sq. in	Lb./cu. in.
3S-O	6,000	16,000	40	6,000	28	4,000	11,000	7,000	0.099
3S-¼H	15,000	18,000	20	15,000	35	10,000	12,000	8,000	0.099
3S-½H	18,000	21,000	16	18,000	40	12,000	14,000	9,000	0.099
3S-¾H	21,000	25,000	14	21,000	47	13,000	15,000	9,500	0.099
3S-H	25,000	29,000	10	25,000	55	14,000	16,000	10,000	0.099
4S-O	10,000	26,000	25	10,000	45	6,000	16,000	14,000	0.098
4S-¼H	22,000	31,000	17	22,000	52	12,000	17,000	14,500	0.098
4S-½H	27,000	34,000	12	27,000	63	14,000	18,000	15,000	0.098
4S-¾H	31,000	37,000	9	31,000	70	17,000	20,000	15,500	0.098
4S-H	34,000	40,000	6	34,000	77	18,000	21,000	16,000	0.098
14S-T	58,000	68,000	13	58,000	130	38,000	45,000	16,000	0.101
17S-O	10,000	26,000	22	10,000	45	7,000	18,000	11,000	0.101
17S-T	37,000	60,000	22	37,000	100	22,000	36,000	15,000	0.101
27S-T[3]	50,000	65,000	11	50,000	115	30,000	39,000	13,000	0.101
A51S-T	40,000	48,000	20	40,000	95	26,000	32,000	10,500	0.097
52S-O	14,000	29,000	30	14,000	45	9,000	18,000	17,000	0.096
52S-¼H	26,000	34,000	18	26,000	62	15,000	20,000	18,000	0.096
52S-½H	29,000	37,000	14	29,000	67	16,000	21,000	19,000	0.096
52S-¾H	34,000	39,000	10	34,000	74	19,000	23,000	20,000	0.096
52S-H	36,000	41,000	8	36,000	85	20,000	24,000	20,500	0.096
53S-O	7,000	16,000	35	7,000	26	5,000	11,000	7,500	0.097
53S-W	20,000	33,000	30	20,000	65	12,000	20,000	10,000	0.097
53S-T	33,000	39,000	20	33,000	80	20,000	24,000	11,000	0.097

[1]For guaranteed minimum values, see Tables 35 to 39.
[2]See page 20 for definitions and significance of terms; also additional data.
[3]Special purpose alloy. See page 19.

TABLE 4—MECHANICAL PROPERTIES OF SAND-CAST ALUMINUM ALLOYS[1]

Alloy	Minimum values for specifications		Typical values (not guaranteed)								
	Tension[2]		Tension[2]			Compression[3]		Hardness	Shear	Fatigue	Weight
	Ultimate Strength Lb./sq. in.	Elongation Per Cent in 2 Inches	Yield Strength (Set = 0.2%) Lb./sq. in.	Ultimate Strength Lb./sq. in.	Elongation Per Cent in 2 Inches	Yield Strength (Set = 0.2%) Lb./sq. in.	Ultimate Strength Lb./sq. in.	Brinell 500 kg., 10 mm. ball	Shearing Strength Lb./sq. in.	Endurance Limit Lb./sq. in.	Lb./cu. in.
43	17,000	3.0	9,000	19,000	6.0	12,000	......	40	14,000	6,500	0.096
195-T4	29,000	6.0	16,000	31,000	8.5	16,000	......	65	24,000	6,000	0.100
195-T6	32,000	3.0	22,000	36,000	5.0	25,000	......	80	30,000	6,500	0.100
195-T62	36,000	[4]	31,000	40,000	2.0	38,000	85,000	95	31,000	7,000	0.100
214	22,000	6.0	12,000	25,000	9.0	12,000	......	50	20,000	5,500	0.095
220-T4	42,000	12.0	25,000	45,000	14.0	26,000	......	75	33,000	7,000	0.092
356-T4	26,000	5.0	16,000	28,000	6.0	18,000	84,000	55	22,000	.....	0.095
356-T6	30,000	3.0	22,000	32,000	4.0	22,000	87,000	70	27,000	8,000	0.095
356-T51	23,000	[4]	20,000	25,000	2.0	22,000	56,000	60	18,000	6,000	0.095

[1]See page 20 for definitions and significance of terms; also additional data.

[2]Tension and hardness values determined from standard half-inch diameter tensile test specimens individually cast in green sand molds and tested without machining off the surface.

[3]Results of tests on specimens having an L/r ratio of 12. Specimens failed in shear except those for which no ultimate strength is shown. Those alloys deformed without fracture at loads up to the maximum capacity of the testing machine.

[4]Not specified. The error in determining low elongations is comparable with the value being measured.

TABLE 5—ROTATING-BEAM FATIGUE DATA

All values of stress in lb./sq. in.

Values given are extreme fiber stresses which polished beam specimens withstand in complete reversal, tension to compression.

Alloy	Approximate maximum stresses which material will withstand for various numbers of cycles				
	100,000 cycles	1,000,000 cycles	10,000,000 cycles	100,000,000 cycles	500,000,000 cycles[1]
3S-½H	17,000	12,000	10,000	9,000	9,000
3S-¾H	17,500	12,500	10,500	9,500	9,500
3S-H	18,000	13,000	11,000	10,000	10,000
4S-¾H	23,000	20,000	18,000	16,000	15,500
14S-T	32,000	27,000	22,500	18,500	16,000
17S-T	37,000	29,000	21,000	17,000	15,000
27S-T[2]	31,000	25,000	19,500	15,000	13,000
A51S-T	25,000	21,000	17,000	13,000	10,500
52S-O	20,000	19,000	18,000	17,500	17,000
52S-¼H	22,000	20,500	19,000	18,500	18,000
52S-½H	24,000	22,000	20,000	19,000	19,000
52S-¾H	26,000	23,000	21,000	20,000	20,000
52S-H	27,000	24,000	22,000	20,500	20,500
53S-T	25,000	20,000	16,000	12,000	11,000

[1]Values given for 500,000,000 cycles are commonly known as endurance limits.
[2]Special purpose alloy. See page 19.

TABLE 6—DIRECT TENSION-COMPRESSION FATIGUE DATA BASED ON POLISHED SPECIMENS TESTED WITH REPEATED AXIAL LOADS

All values of stress in lb./sq. in.

Stresses considered algebraically: plus (+) means tension, minus (—) means compression.

	Minimum stress in each cycle	Approximate maximum stresses which material will withstand for various numbers of cycles				
		100,000 cycles	1,000,000 cycles	10,000,000 cycles	100,000,000 cycles	500,000,000 cycles
17S-T alloy	—25,000	+28,000	+19,000	+11,000	+ 4,000	+ 2,000
	—20,000	+31,000	+23,000	+15,000	+ 8,000	+ 6,000
	—15,000	+34,000	+26,000	+19,000	+13,000	+10,000
	—10,000	+37,000	+30,000	+23,000	+17,000	+14,000
	— 5,000	+40,000	+33,000	+26,000	+21,000	+18,000
	0	+42,000	+35,000	+29,000	+24,000	+22,000
	+ 5,000	+44,000	+38,000	+32,000	+28,000	+26,000
	+10,000	+47,000	+41,000	+35,000	+31,000	+29,000
	+15,000	+49,000	+43,000	+38,000	+35,000	+33,000
	+20,000	+51,000	+46,000	+42,000	+38,000	+36,000
	+25,000	+53,000	+48,000	+44,000	+41,000	+39,000
27S-T alloy[1]	—25,000	+27,000	+18,000	+ 9,000	+ 4,000	+ 2,000
	—20,000	+31,000	+22,000	+14,000	+ 8,000	+ 6,000
	—15,000	+35,000	+26,000	+18,000	+13,000	+10,000
	—10,000	+38,000	+29,000	+22,000	+17,000	+14,000
	— 5,000	+41,000	+33,000	+26,000	+21,000	+18,000
	0	+45,000	+37,000	+30,000	+24,000	+22,000
	+ 5,000	+48,000	+40,000	+34,000	+28,000	+26,000
	+10,000	+50,000	+44,000	+38,000	+32,000	+30,000
	+15,000	+52,000	+47,000	+42,000	+36,000	+34,000
	+20,000	+54,000	+50,000	+46,000	+39,000	+37,000
	+25,000	+56,000	+53,000	+50,000	+43,000	+41,000
52S-¾H alloy	—25,000	+16,000	+ 9,000	+ 7,000	+ 6,000	+ 5,000
	—20,000	+21,000	+14,000	+12,000	+11,000	+10,000
	—15,000	+25,000	+19,000	+17,000	+16,000	+15,000
	—10,000	+29,000	+24,000	+22,000	+21,000	+20,000
	— 5,000	+33,000	+28,000	+26,000	+25,000	+24,000
	0	+36,000	+33,000	+31,000	+30,000	+29,000
	+ 5,000	+37,000	+35,000	+33,000	+32,000	+31,000
53S-T alloy	—20,000	+19,000	+12,000	+ 6,000	+ 2,000	+ 1,000
	—15,000	+23,000	+16,000	+11,000	+ 7,000	+ 6,000
	—10,000	+26,000	+20,000	+15,000	+11,000	+10,000
	— 5,000	+28,000	+24,000	+19,000	+16,000	+14,000
	0	+30,000	+26,000	+23,000	+20,000	+18,000
	+ 5,000	+31,000	+29,000	+26,000	+24,000	+22,000
	+10,000	+32,000	+31,000	+29,000	+28,000	+26,000

[1]Special purpose alloy. See page 19.

TABLE 7—TYPICAL TENSILE PROPERTIES OF ALUMINUM ALLOYS AT ELEVATED TEMPERATURES AFTER PROLONGED HEATING AT TESTING TEMPERATURE

Alloy	Property	75°F.	300°F.	400°F.	500°F.	600°F.
3S-O	Tensile strength, lb./sq. in.	16,000	11,000	8,000	5,500	4,000
	Yield strength, lb./sq. in.	6,000	5,000	4,500	3,500	2,500
	Elongation in 2 inches, %	40	47	50	60	60
3S-½H	Tensile strength, lb./sq. in.	21,000	18,000	14,000	10,500	6,000
	Yield strength, lb./sq. in.	18,000	15,000	9,000	5,000	3,000
	Elongation in 2 inches, %	16	17	22	25	40
3S-H	Tensile strength, lb./sq. in.	29,000	23,000	17,000	10,500	4,500
	Yield strength, lb./sq. in.	25,000	16,000	8,000	5,000	3,000
	Elongation in 2 inches, %	10	12	15	25	55
4S-O	Tensile strength, lb./sq. in.	26,000	22,500	15,000	10,500	6,000
	Yield strength, lb./sq. in.	10,000	10,000	8,500	7,000	3,500
	Elongation in 2 inches, %	25	36	60	85	90
4S-½H	Tensile strength, lb./sq. in.	34,000	26,000	21,000	13,000	7,000
	Yield strength, lb./sq. in.	27,000	19,000	10,500	5,000	3,500
	Elongation in 2 inches, %	12	20	30	60	90
4S-H	Tensile strength, lb./sq. in.	40,000	32,000	23,000	11,500	6,500
	Yield strength, lb./sq. in.	34,000	22,000	9,500	5,000	3,500
	Elongation in 2 inches, %	6	14	27	70	90
17S-T	Tensile strength, lb./sq. in.	60,000	40,000	25,000	13,000	5,500
	Yield strength, lb./sq. in.	37,000	33,500	20,000	9,500	3,500
	Elongation in 2 inches, %	22	16	25	35	90
27S-T[1]	Tensile strength, lb./sq. in.	65,000	40,000	17,000	7,000	5,000
	Yield strength, lb./sq. in.	50,000	32,000	12,000	4,500	4,000
	Elongation in 2 inches, %	11	17	30	60	65
52S-O	Tensile strength, lb./sq. in.	29,000	23,000	18,000	12,000	7,500
	Yield strength, lb./sq. in.	14,000	13,500	11,000	8,000	4,000
	Elongation in 2 inches, %	30	55	65	100	105
52S-¾H	Tensile strength, lb./sq. in.	39,000	32,000	25,000	12,000	8,000
	Yield strength, lb./sq. in.	34,000	27,000	11,000	8,000	4,500
	Elongation in 2 inches, %	10	16	35	80	100
53S-T	Tensile strength, lb./sq. in.	39,000	25,000	13,000	6,000	3,500
	Yield strength, lb./sq. in.	33,000	22,000	10,000	3,500	2,500
	Elongation in 2 inches, %	20	17	30	70	75
195-T4	Tensile strength, lb./sq. in.	31,000	24,000	15,000	9,500	4,000
	Yield strength, lb./sq. in.	16,000	13,000	9,000	6,000	3,000
	Elongation in 2 inches, %	8	9	20	25	80
214	Tensile strength, lb./sq. in.	25,000	23,000	18,500	13,500	9,000
	Yield strength, lb./sq. in.	12,000	15,000	12,500	8,000	4,000
	Elongation in 2 inches, %	9	7	9	12	17
356-T4	Tensile strength, lb./sq. in.	28,000	21,000	13,000	8,000	4,500
	Yield strength, lb./sq. in.	16,000	15,000	9,000	5,500	3,000
	Elongation in 2 inches, %	6	7	8	20	45

[1]Special purpose alloy. See page 19.

TABLE 8—THERMAL EXPANSION OF 17S AND 27S[1] ALUMINUM ALLOYS

Temperature Range from −50°F. to +150°F.

For 3S and 4S multiply by 1.12. For 52S and 53S multiply by 1.10. For structural steel multiply by 0.588.

Length in feet	Change in Length in inches — Temperature Change in degrees Fahrenheit									
	10	20	30	40	50	60	70	80	90	100
10	0.014	0.027	0.041	0.055	0.068	0.082	0.096	0.109	0.123	0.137
20	0.027	0.055	0.082	0.109	0.137	0.164	0.192	0.219	0.246	0.274
30	0.041	0.082	0.123	0.164	0.205	0.246	0.287	0.328	0.369	0.410
40	0.055	0.109	0.164	0.219	0.274	0.328	0.383	0.438	0.492	0.547
50	0.068	0.137	0.205	0.274	0.342	0.410	0.479	0.547	0.616	0.684
60	0.082	0.164	0.246	0.328	0.410	0.492	0.575	0.657	0.739	0.821
70	0.096	0.192	0.287	0.383	0.479	0.575	0.670	0.766	0.862	0.958
80	0.109	0.219	0.328	0.438	0.547	0.657	0.766	0.876	0.985	1.094
90	0.123	0.246	0.369	0.492	0.616	0.739	0.862	0.985	1.108	1.231
100	0.137	0.274	0.410	0.547	0.684	0.821	0.958	1.094	1.231	1.368

Coefficient of thermal expansion per degree Fahrenheit: Alloys 17S and 27S[1] = 0.0000114; alloys 52S and 53S = 0.0000125; alloys 3S and 4S = 0.0000128. Medium structural steel = 0.0000067.

[1]Special purpose alloy. See page 19.

TABLE 9—APPROXIMATE RADII FOR 90° COLD BEND OF ALUMINUM ALLOY SHEET

Minimum permissible radius[1] varies with nature of forming operation, type of forming equipment, and design and condition of tools. Minimum working radius for given material or hardest alloy and temper for a given radius can be ascertained only by actual trial under contemplated conditions of fabrication.

Alloy	Bend classification[2]	Alloy	Bend classification[2]
3S-O	A	27S-T[4]	K
3S-¼H	B		
3S-½H	C	52S-O	A
3S-¾H	E	52S-¼H	C
3S-H	G	52S-½H	D
		52S-¾H	F
4S-O	B	52S-H	G
4S-¼H	D		
4S-½H	E	53S-O	A
4S-¾H	G	53S-W	F
4S-H	H	53S-T	G
17S-O	B		
17S-T[3]	H		

[1]See page 14.

[2]For corresponding bend radii see table below.

[3]Immediately after quenching, this alloy can be formed over appreciably smaller radii.

[4]Special purpose alloy. See page 19.

RADII REQUIRED FOR 90° BEND IN TERMS OF THICKNESS, t

		Approximate Thickness					
B & S Gage		26	20	14	8	5	2
Inch		0.016	0.032	0.064	0.128	0.189	0.258
Inch		1/64	1/32	1/16	1/8	3/16	1/4
Bend Classification	A	0	0	0	0	0	0
	B	0	0	0	0	0–1t	0–1t
	C	0	0	0	0–1t	0–1t	½t–1½t
	D	0	0	0–1t	½t–1½t	1t–2t	1½t–3t
	E	0–1t	0–1t	½t–1½t	1t–2t	1½t–3t	2t–4t
	F	0–1t	½t–1½t	1t–2t	1½t–3t	2t–4t	2t–4t
	G	½t–1½t	1t–2t	1½t–3t	2t–4t	3t–5t	4t–6t
	H	1t–2t	1½t–3t	2t–4t	3t–5t	4t–6t	4t–6t
	K	2t–4t	3t–5t	3t–5t	4t–6t	5t–7t	6t–10t

DESIGN OF
ALUMINUM ALLOY STRUCTURES

THE SELECTION OF ALLOWABLE WORKING STRESSES

In structural design, it is common practice to compute the stresses to which the various parts of a structure will probably be subjected during its life. The shape and size of the various parts of the structure are adjusted so that these computed stresses do not exceed certain limiting values called allowable working stresses. These allowable working stresses, then, become the basis for proportioning most of the parts of a structure.

The selection of allowable working stresses for structural materials is a matter of prime importance to the designer, because these stresses must provide a suitable margin of safety against failure of the structure. Obviously, an allowable stress for one structural application of a given material may be too conservative for another application. Since structural aluminum is used in a great variety of ways, no attempt is made in this book to recommend definite allowable working stresses for the various alloys. Instead, data are presented to show the strength of members made from the various wrought alloys in tension, compression, buckling, shear, bearing, and fatigue. This information, which is based on both theoretical and laboratory studies, should provide the engineer with the essential information necessary for an intelligent selection of allowable working stresses in any given structure.

Factor of Safety

The allowable working stresses in any material for any condition of loading are generally selected as high as may be consistent with the strength of the material for that condition of loading. The ratio of the strength of the material to the allowable working stress is usually called the factor of safety.

A given allowable working stress in tension presents one factor of safety with respect to yield strength and a quite different factor of safety with respect to ultimate strength. Similarly, a given allowable stress for compression or shear may present one factor of safety against buckling and a higher factor of safety against ultimate failure. For these reasons, it is obviously impossible to obtain the same factor of safety throughout a set of allowable working stresses for any given material. In fact, a uniform factor of safety would probably not be desirable even if it could be attained. For

example, in many applications, the factor of safety against buckling of plate girder webs can be permitted to be smaller than that against tensile fracture of the material, and in such instances the use of the same factor of safety would result in uneconomical design.

In selecting suitable allowable working stresses for aluminum alloys for various structural applications, the following factors will be found important:

(a) *The precision with which the assumed loadings represent the actual service loadings, both present and future.* When there is much uncertainty about actual loadings, allowable working stresses should be selected more conservatively than in cases where loadings are known with considerable accuracy. On the other hand, if the uncertainty surrounding the actual loading leads to the adoption of very heavy assumed loadings, then part of the factor of safety is already included in these loadings and it would be wasteful of material to repeat this factor of safety by using very low allowable working stresses. Where moving loads are encountered, the selection of a suitable impact factor to represent the dynamic effects is highly important.

(b) *The precision with which the stresses in the structure are calculated.* Allowable working stresses should always be conservatively selected if in the design calculations the stresses are determined by methods which are known to give only approximate results. Refinements in calculations of stresses, if carried out consistently, should permit the use of higher allowable working stresses. For example, in the design of a riveted truss, allowable working stresses should be higher if both the primary and secondary stresses are calculated than if only the primary stresses are calculated.

(c) *The importance of the structure being designed.* In designing important major structures in which failures might cause considerable property damage and even loss of life, the allowable working stresses are selected more conservatively than would be the case in less important structures in which the consequences of failure are less severe. Similarly, some members or parts of members may be more important than others, and it may be desirable to adjust the factor of safety accordingly.

Tension

In selecting an allowable stress suitable for the net section of tension members, the most important mechanical property of the material is the tensile yield strength, which is given in Table 3,

page 23, for the various wrought Alcoa Aluminum Alloys. There is no sudden yielding in the aluminum alloys, and therefore, the yield strength is defined as the stress at which the permanent set is 0.2 per cent of the original gage length. When a stress of this magnitude is first applied, a permanent elongation of about $\frac{1}{64}$ inch for each 8 inches of length will occur. Since permanent elongations of even this small amount are considered undesirable, the allowable tensile working stresses for aluminum alloys are usually established by dividing the yield strength by a factor of safety suitable to the conditions of the problem in hand. In selecting tensile working stresses, some engineers use the typical yield strength of the material (Table 3), and others use the guaranteed minimum value (Tables 35 to 39). The factor of safety will, of course, be influenced by this choice.

The spread between yield strength and tensile strength in the aluminum alloys is large enough to provide a considerable extra factor of safety against tensile fracture. Some engineers determine the allowable tensile working stress separately for yield and ultimate and use the lower of the two values, the factor of safety in the case of the ultimate being larger than that used in the case of the yield by some arbitrary amount. For example, in some fields of design a factor of safety of 2 on the yield strength, or 3 on the ultimate strength is used. These are matters concerning which no fixed rules can be made; the engineer must rely on his own judgment and experience.

Compression

The structural Alcoa Aluminum Alloys, in common with other ductile materials, do not possess a definite ultimate compressive strength. When short compact specimens of aluminum alloys are highly stressed in compression, the material flows out laterally so that the increased area continues to support the increasing load. Therefore, in Table 3 no compressive ultimate strength is given.

In Table 3 it will be noted that the compressive yield strengths of the various alloys are equal to the tensile yield strengths. Therefore, it is usually satisfactory to select an allowable working stress in compression equal to that selected in tension. This basic allowable compressive working stress applies only to short compact members, the longer, less compact members being designed according to the column formula or other buckling formulas discussed on the following page.

Columns

The column strength of aluminum alloys, as with other metals, is a function not only of the properties of the material but also of the slenderness ratio of the member. Table 10, page 37, gives the column formulas for the various Alcoa Alloys. Using these formulas, the ultimate strength curve for axially loaded columns of any given alloy can be constructed readily.

It will be noted in Table 10 that the column formulas are expressed in terms of $\frac{KL}{r}$, which is called "effective slenderness ratio." The factor K represents the effect of the end conditions of the member, the following being some of the values of this factor:

For both ends completely fixed	K=0.5
For one end fixed and one end pinned	K=0.7
For both ends pinned	K=1.0
For one end fixed and one end free (cantilever compression member)	K=2.0

The designer can select a value of K corresponding to any given set of end conditions which may be encountered. In making his selection the designer may find it helpful to think of KL as the portion of the member which functions as if it were pin-ended, that is, the length between points of contraflexure when the member is in its deflected position. This deflected position should be visualized in terms of the conditions which would exist just before failure.

Most compression members in modern framed structures have partially fixed ends so that a K value should be selected somewhere between fixed and pinned. Since few compression members are completely fixed, the value of K should rarely be selected less than 0.6. In fact, a study of the behavior of compression members in framed structures indicates that many of such members are more nearly pinned than fixed, so that values of K less than 0.75 are to be regarded with suspicion unless restricted to slender members rigidly connected at both ends to members relatively much stiffer.

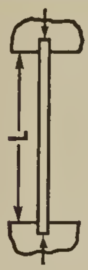
Table 11, page 38, gives values of ultimate column strength corresponding to various effective slenderness ratios for the wrought Alcoa Aluminum Alloys.

In selecting allowable working stresses for aluminum alloy columns, it is necessary to divide the ultimate column strengths referred to above by a suitable factor of safety. The factor of safety selected should be at least as conservative as that used with the tensile yield strength in selecting the basic tensile and compressive working stresses.

TABLE 10—ULTIMATE STRENGTH FORMULAS FOR AXIALLY LOADED ALUMINUM ALLOY COLUMNS

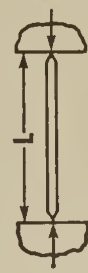
Representative of material having the typical properties shown in Table 3

K=0.5



Members are assumed to be compact enough so that no local failure will occur.

$\frac{P}{A}$ = ultimate strength of column in lb./sq. in.
L = unsupported length of column in inches
r = corresponding radius of gyration in inches
K = 0.5 for both ends fixed
K = 1.0 for both ends hinged



K=1.0

Alloy	For $\frac{KL}{r}$ less than C	C	For $\frac{KL}{r}$ greater than C
3S-O	$\frac{P}{A} = 6{,}200 - 18\frac{KL}{r}$	194	$\frac{P}{A} = \frac{102{,}000{,}000}{\left(\frac{KL}{r}\right)^2}$
3S-¼H	$\frac{P}{A} = 16{,}100 - 78\frac{KL}{r}$	138	
3S-½H	$\frac{P}{A} = 19{,}600 - 105\frac{KL}{r}$	125	"
3S-¾H	$\frac{P}{A} = 23{,}200 - 135\frac{KL}{r}$	115	"
3S-H	$\frac{P}{A} = 28{,}100 - 179\frac{KL}{r}$	104	"
4S-O	$\frac{P}{A} = 10{,}500 - 41\frac{KL}{r}$	170	"
4S-¼H	$\frac{P}{A} = 24{,}400 - 145\frac{KL}{r}$	112	"
4S-½H	$\frac{P}{A} = 30{,}600 - 204\frac{KL}{r}$	100	"
4S-¾H	$\frac{P}{A} = 35{,}800 - 258\frac{KL}{r}$	92	"
4S-H	$\frac{P}{A} = 39{,}800 - 302\frac{KL}{r}$	88	"
17S-T	$\frac{P}{A} = 43{,}800 - 350\frac{KL}{r}$	83	"
27S-T[1]	$\frac{P}{A} = 62{,}500 - 596\frac{KL}{r}$	70	"
52S-O	$\frac{P}{A} = 15{,}000 - 70\frac{KL}{r}$	143	"
52S-¼H	$\frac{P}{A} = 29{,}400 - 192\frac{KL}{r}$	102	"
52S-½H	$\frac{P}{A} = 33{,}200 - 230\frac{KL}{r}$	96	"
52S-¾H	$\frac{P}{A} = 39{,}800 - 302\frac{KL}{r}$	88	"
52S-H	$\frac{P}{A} = 42{,}500 - 334\frac{KL}{r}$	85	"
53S-W	$\frac{P}{A} = 22{,}000 - 124\frac{KL}{r}$	118	"
53S-T	$\frac{P}{A} = 38{,}400 - 287\frac{KL}{r}$	90	"

[1]Special purpose alloy. See page 19.

TABLE 11—VALUES OF ULTIMATE COLUMN STRENGTH CORRESPONDING TO FORMULAS IN TABLE 10

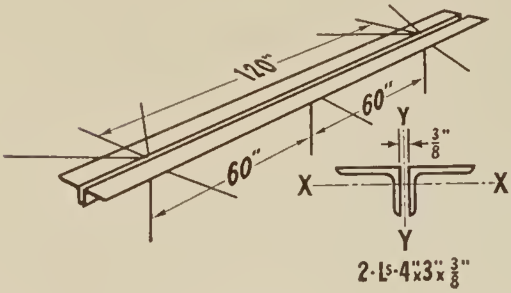
$\frac{KL}{r}$	3S-O	3S-¼H	3S-½H	3S-¾H	3S-H	4S-O	4S-¼H	4S-½H	4S-¾H	4S-H
0	6,200	16,100	19,600	23,200	28,100	10,500	24,400	30,600	35,800	39,800
5	6,110	15,710	19,080	22,530	27,210	10,300	23,680	29,580	34,510	38,290
10	6,020	15,320	18,550	21,850	26,310	10,090	22,950	28,560	33,220	36,780
15	5,930	14,930	18,030	21,180	25,420	9,890	22,230	27,540	31,930	35,270
20	5,840	14,540	17,500	20,500	24,520	9,680	21,500	26,520	30,640	33,760
25	5,750	14,150	16,980	19,830	23,630	9,480	20,780	25,500	29,350	32,250
30	5,660	13,760	16,450	19,150	22,730	9,270	20,050	24,480	28,060	30,740
35	5,570	13,370	15,930	18,480	21,840	9,070	19,330	23,460	26,770	29,230
40	5,480	12,980	15,400	17,800	20,940	8,860	18,600	22,440	25,480	27,720
45	5,390	12,590	14,880	17,130	20,050	8,660	17,880	21,420	24,190	26,210
50	5,300	12,200	14,350	16,450	19,150	8,450	17,150	20,400	22,900	24,700
55	5,210	11,810	13,830	15,780	18,260	8,250	16,430	19,380	21,610	23,190
60	5,120	11,420	13,300	15,100	17,360	8,040	15,700	18,360	20,320	21,680
65	5,030	11,030	12,780	14,430	16,470	7,840	14,980	17,340	19,030	20,170
70	4,940	10,640	12,250	13,750	15,570	7,630	14,250	16,320	17,740	18,660
75	4,850	10,250	11,730	13,080	14,680	7,430	13,530	15,300	16,450	17,150
80	4,760	9,860	11,200	12,400	13,780	7,220	12,800	14,280	15,160	15,640
85	4,670	9,470	10,680	11,730	12,890	7,020	12,080	13,260	13,870	14,130
90	4,580	9,080	10,150	11,050	11,990	6,810	11,350	12,240	12,580	12,590
95	4,490	8,690	9,630	10,380	11,100	6,610	10,630	11,220	11,300	11,300
100	4,400	8,300	9,100	9,700	10,200	6,400	9,900	10,200	10,200	10,200
120	4,040	6,740	7,000	7,080	7,080	5,580	7,080	7,080	7,080	7,080
140	3,680	5,180	5,200	5,200	5,200	4,760	5,200	5,200	5,200	5,200
160	3,320	3,980	3,980	3,980	3,980	3,940	3,980	3,980	3,980	3,980
180	2,960	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150
200	2,550	2,550	2,550	2,550	2,550	2,550	2,550	2,550	2,550	2,550
220	2,110	2,110	2,110	2,110	2,110	2,110	2,110	2,110	2,110	2,110
240	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770
260	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510
280	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300

TABLE 11—VALUES OF ULTIMATE COLUMN STRENGTH CORRESPONDING TO FORMULAS IN TABLE 10—Continued

$\frac{KL}{r}$	17S-T	27S-T[1]	52S-O	52S-¼H	52S-½H	52S-¾H	52S-H	53S-W	53S-T
0	43,800	62,500	15,000	29,400	33,200	39,800	42,500	22,000	38,400
5	42,050	59,520	14,650	28,440	32,050	38,290	40,830	21,380	36,970
10	40,300	56,540	14,300	27,480	30,900	36,780	39,160	20,760	35,530
15	38,550	53,560	13,950	26,520	29,750	35,270	37,490	20,140	34,100
20	36,800	50,580	13,600	25,560	28,600	33,760	35,820	19,520	32,660
25	35,050	47,600	13,250	24,600	27,450	32,250	34,150	18,900	31,230
30	33,300	44,620	12,900	23,640	26,300	30,740	32,480	18,280	29,790
35	31,550	41,640	12,550	22,680	25,150	29,230	30,810	17,660	28,360
40	29,800	38,660	12,200	21,720	24,000	27,720	29,140	17,040	26,920
45	28,050	35,680	11,850	20,760	22,850	26,210	27,470	16,420	25,490
50	26,300	32,700	11,500	19,800	21,700	24,700	25,800	15,800	24,050
55	24,550	29,720	11,150	18,840	20,550	23,190	24,130	15,180	22,620
60	22,800	26,740	10,800	17,880	19,400	21,680	22,460	14,560	21,180
65	21,050	23,760	10,450	16,920	18,250	20,170	20,790	13,940	19,750
70	19,300	20,780	10,100	15,960	17,100	18,660	19,120	13,320	18,310
75	17,550	18,130	9,750	15,000	15,950	17,150	17,450	12,700	16,880
80	15,800	15,940	9,400	14,040	14,800	15,640	15,780	12,080	15,440
85	14,120	14,120	9,050	13,080	13,650	14,130	14,110	11,460	14,010
90	12,590	12,590	8,700	12,120	12,500	12,590	12,590	10,840	12,590
95	11,300	11,300	8,350	11,160	11,350	11,300	11,300	10,220	11,300
100	10,200	10,200	8,000	10,200	10,200	10,200	10,200	9,600	10,200
120	7,080	7,080	6,600	7,080	7,080	7,080	7,080	7,080	7,080
140	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200
160	3,980	3,980	3,980	3,980	3,980	3,980	3,980	3,980	3,980
180	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150
200	2,550	2,550	2,550	2,550	2,550	2,550	2,550	2,550	2,550
220	2,110	2,110	2,110	2,110	2,110	2,110	2,110	2,110	2,110
240	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770
260	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510
280	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300

[1]Special purpose alloy. See page 19.

Example 1. Design the compression chord of a truss for an axial load of 45,000 lb., using a factor of safety of 2.5.



Try two angles 4″ × 3″ × 3/8″, 17S-T alloy, area = 4.98 sq. in.

Calculated stress $= \frac{P}{A} = \frac{45,000}{4.98}$
$= 9040$ lb./sq. in.

Axis X,
$L = 60''$, $r = 0.86$, assume $K = 0.8$.
$\frac{KL}{r} = \frac{0.8 \times 60}{0.86} = 56.$

Axis Y,
$L = 120''$, $r = 1.91$, assume $K = 0.8$.
$\frac{KL}{r} = \frac{0.8 \times 120}{1.91} = 50.$

Greatest value of $\frac{KL}{r}$ is 56, about Axis X.

Ultimate column strength (Table 10, 17S-T alloy) $= 43,800 - 350 \times 56$
$= 24,200$ lb./sq. in.

Allowable working stress (factor of safety of 2.5) $= \frac{24,200}{2.5}$
$= 9680$ lb./sq. in.

Since this allowable stress is greater than the calculated stress of 9040 lb./sq. in., member selected is satisfactory.

Example 1a. Check member used above for 53S-T alloy instead of 17S-T alloy.

Ultimate column strength for 53S-T alloy (Table 10, 53S-T) $= 38,400 - 287 \times 56 = 22,330$ lb./sq. in.

Allowable stress for 53S-T alloy $= \frac{22,330}{2.5} = 8930$ lb./sq. in.

Since this allowable stress is smaller than the calculated stress of 9040 lb./sq. in., a slightly larger member is necessary in 53S-T alloy to avoid reducing the factor of safety.

In the foregoing discussion of column strength, it is assumed that members are compact enough so that no local buckling failures will occur. When columns are made up of thin sections, failures sometimes occur by local buckling at stresses below those indicated by the column formulas. In order to design such members safely and economically, it is necessary to check the allowable compressive working stress not only from the column formula, but also from

local buckling formulas, the final allowable working stress for the member being the lower of the values arrived at in this manner. These local buckling formulas are discussed below.

Local Buckling of Flat Plates Under Edge Compression

When a flat plate is used as a component part of a column or other compression member, it may buckle locally under edge compression at stresses below the compressive yield strength of the material. Such buckling occurs in the form of local waves or wrinkles which are practically independent of the length of the member. These local buckling failures in plates may be treated conveniently as local column failures, using the ordinary column formula for the material, provided the proper equivalent slenderness ratio is used. A list of these equivalent slenderness ratios for various conditions of edge support is given below in terms of "b," the unsupported width of the plate, and "t," the thickness of the plate, both in inches.

1. Both edges simply supported (e.g., the web of an H-beam with relatively thin flanges).

$$\text{Equivalent slenderness ratio } \frac{KL}{r} = 1.65\frac{b}{t}$$

2. Both edges built in (e.g., the web of an H-beam with relatively thick flanges).

$$\text{Equivalent slenderness ratio } \frac{KL}{r} = 1.25\frac{b}{t}$$

3. One edge simply supported, other edge free (e.g., longest outstanding leg of a single angle strut).

$$\text{Equivalent slenderness ratio } \frac{KL}{r} = 5.1\frac{b}{t}$$

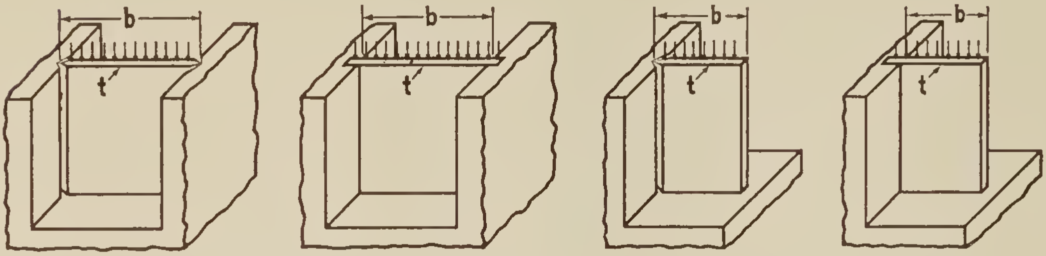
4. One edge built in, other edge free (e.g., the outstanding leg of an angle with other leg riveted to thicker members).

$$\text{Equivalent slenderness ratio } \frac{KL}{r} = 2.9\frac{b}{t}$$

The above values of equivalent slenderness ratio, $\frac{KL}{r}$, may be substituted directly in the ultimate column strength formulas for the various aluminum alloys to determine the critical stresses at which flat plates under edge compression will begin to buckle noticeably. In using these values it should be remembered that they are based on theoretical conditions of edge restraint. In actual structural de-

TABLE 12—VALUES OF EQUIVALENT SLENDERNESS RATIO, $\frac{KL}{r}$, FOR FLAT PLATES SUBJECTED TO EDGE COMPRESSION

$$\frac{b}{t} = \frac{\text{unsupported width of plate}}{\text{thickness of plate}}$$



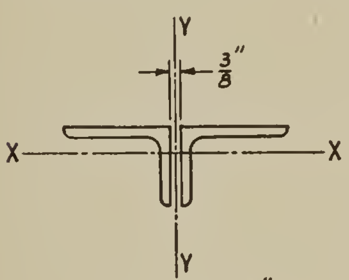
Both edges simply supported $\frac{KL}{r} = 1.65\frac{b}{t}$				Both edges built in $\frac{KL}{r} = 1.25\frac{b}{t}$				One edge simply supported, other edge free $\frac{KL}{r} = 5.1\frac{b}{t}$		One edge built in, other edge free $\frac{KL}{r} = 2.9\frac{b}{t}$	
$\frac{b}{t}$	$\frac{KL}{r}$	$\frac{b}{t}$	$\frac{KL}{r}$	$\frac{b}{t}$	$\frac{KL}{r}$	$\frac{b}{t}$	$\frac{KL}{r}$	$\frac{b}{t}$	$\frac{KL}{r}$	$\frac{b}{t}$	$\frac{KL}{r}$
2	3	32	53	2	3	32	40	2	10	2	6
4	7	34	56	4	5	34	43	4	20	4	12
6	10	36	59	6	8	36	45	6	31	6	17
8	13	38	63	8	10	38	48	8	41	8	23
10	17	40	66	10	13	40	50	10	51	10	29
12	20	45	74	12	15	45	56	12	61	12	35
14	23	50	83	14	18	50	63	14	71	14	41
16	26	55	91	16	20	55	69	16	82	16	46
18	30	60	99	18	23	60	75	18	92	18	52
20	33	65	107	20	25	65	81	20	102	20	58
22	36	70	116	22	28	70	88	22	112	22	64
24	40	75	124	24	30	75	94	24	122	24	70
26	43	80	132	26	33	80	100	26	133	26	75
28	46	90	149	28	35	90	113	28	143	28	81
30	50	100	165	30	38	100	125	30	153	30	87

These values of equivalent slenderness ratio, $\frac{KL}{r}$, may be used directly in the column formulas (Table 10) to determine the critical compressive stresses at which plates of various aluminum alloys will buckle.

sign, it is necessary, of course, to select constants intermediate between fixed and simply supported conditions, depending on the actual conditions of the member being designed. Table 12 gives values of equivalent slenderness ratio for flat plates under edge compression.

The factors of safety to be used with the foregoing critical buckling stresses will depend largely on the type of structure being designed. Generally, it is not necessary to provide as large a factor of safety against flat plate buckling as against tensile fracture or column failure, because many compression members incorporating flat plates are capable of carrying considerable load beyond that at which buckling begins. Quite often appearance is the controlling factor in the selection of the factor of safety to be used with the critical buckling stresses.

Example 2. Check member used in Example 1, page 40, to see if buckling of outstanding leg controls the design.



2-Ls-4″x3″x 3/8″

$\frac{b}{t}$ for 4″ leg $= \frac{4.00-0.375}{0.375} = 9.7$

The equivalent slenderness ratio for this member is between the following (page 41):

$5.1\frac{b}{t}$ (one edge simply supported, other edge free)

$2.9\frac{b}{t}$ (one edge built in, other edge free)

This member is nearer the first condition, the edge of the 4″ leg being restrained only by the 3″ leg plus what little restraint comes from the stitch rivets used to hold the two angles together.

Assume equivalent slenderness ratio $= 4.5\ \frac{b}{t} = 4.5 \times 9.7 = 44.$

This value is less than the effective slenderness ratio of the member as a whole, 56, so the member will have a greater factor of safety against local buckling than against column action, therefore local buckling does not control the design.

Example 2a. Check member in Example 1 to see if local buckling would have controlled design if the length of member between panel points had been 32″ instead of 60″.

For L = 32″, the effective slenderness ratio of the member would have been $\frac{0.8 \times 32}{0.86} = 30.$

The equivalent slenderness ratio of the 4″ outstanding leg, however, would not be changed from the value, 44, arrived at in Example 2.

Since this value is now greater than the effective slenderness ratio of the whole member, local buckling controls the design.

The critical buckling stress for this member is found by substituting the equivalent slenderness ratio, 44, in the column formula for 17S-T alloy (Table 10, 17S-T).

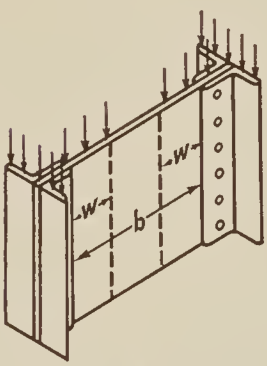
Critical stress $= 43{,}800 - 350 \times 44 = 28{,}400$ lb./sq. in.

Allowable working stress (factor of safety of 2.5)

$$= \frac{28{,}400}{2.5} = 11{,}360 \text{ lb./sq. in.}$$

This allowable stress is so much larger than the calculated stress, 9040 lb./sq. in. (Example 1), that a smaller member might well be used.

TABLE 13—EFFECTIVE WIDTHS OF FLAT PLATES IN EDGE COMPRESSION



Effective width of plate along each edge which may be considered acting with the flange in resisting ultimate compression failure, the center portion of the plate assumed to have buckled.

$$W = \frac{2700}{\sqrt{\text{yield strength}}}\, t$$

where t = thickness of plate in inches.

Note.—Effective width, W, must never be taken greater than $\frac{b}{2}$.

Alloy	W	Alloy	W	Alloy	W	Alloy	W
3S-¼H	22.0t	4S-¼H	18.2t	52S-¼H	16.7t	17S-T	14.0t
3S-½H	20.1t	4S-½H	16.4t	52S-½H	15.9t	27S-T[1]	12.1t
3S-¾H	18.6t	4S-¾H	15.3t	52S-¾H	14.6t	53S-W	19.1t
3S-H	17.1t	4S-H	14.6t	52S-H	14.2t	53S-T	14.9t

[1]Special purpose alloy. See page 19.

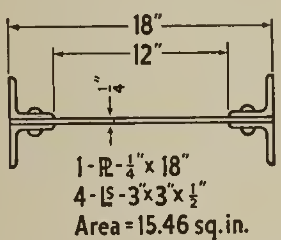
In designing members in which both edges of a plate are built into heavier members and in which there is no problem of appearance, engineers sometimes disregard buckling of the flat plate altogether and design the member, using only a portion of the flat plate area along the built-in edges as being effective, the center portion of the plate being assumed to have no load-carrying capacity. In such cases the width of plate which may be considered effective along each edge may be found by means of the following formula:

$$\text{Effective width of plate} = \frac{2700}{\sqrt{YS}}\,t,$$

where t = thickness of plate in inches,
YS = yield strength of material in lb./sq. in.

Table 13, page 44, gives values of effective width of plate for the various wrought Alcoa Aluminum Alloys based on the typical yield strengths given in Table 3. In using these effective widths it should be remembered that they must never exceed one-half the clear width of the plate between the built-in edges; that is, they must never overlap at the center of the clear width.

Example 3. Check the 17S-T member shown in the sketch to determine the factor of safety against buckling of the flat plate when the member is subjected to an axial load of 200,000 lb.



Calculated compressive stress

$$= \frac{P}{A} = \frac{200{,}000}{15.46} = 12{,}900 \text{ lb./sq. in.}$$

The equivalent slenderness ratio of the flat plate will lie between the values $1.65\,\frac{b}{t}$ and $1.25\,\frac{b}{t}$ (edges simply supported and edges fixed, page 41).

$$\text{Assume equivalent slenderness ratio} = 1.35\,\frac{b}{t} = 1.35\,\frac{12}{0.25} = 65.$$

Critical stress (Table 10, 17S-T alloy) $= 43{,}800 - 350 \times 65$
$= 21{,}000$ lb./sq. in.

$$\text{Factor of safety against buckling of the plate} = \frac{21{,}000}{12{,}900} = 1.63.$$

Example 4. Check the 17S-T member used in Example 3 to determine factor of safety against compression failure, failure assumed to occur at the yield strength of the material (37,000 lb./sq. in.).

Effective width of plate along each edge (Table 13)
$= 14.0t = 14.0 \times 0.25 = 3.5''$.

Total effective area of plate $= 2 \times (3.5 + 3) \times 0.25 =$	3.25 sq. in.
Area of angles	= 10.96 sq. in.
Total effective area of member, A_e,	= 14.21 sq. in.

$$\text{Calculated compressive stress} = \frac{P}{A_e} = \frac{200{,}000}{14.21} = 14{,}070 \text{ lb./sq. in.}$$

$$\text{Factor of safety against failure} = \frac{37{,}000}{14{,}070} = 2.6$$

Note.—If 27S-T[1] alloy had been used instead of 17S-T, the effective width would have been less $(12.1t = 3.03'')$, but the factor of safety against failure would have been greater (50,000/14,300 = 3.5).

[1]Special purpose alloy. See page 19.

Local Buckling of Curved Plates Under Edge Compression

Curved plates are better suited for resisting local buckling failures under edge compression than are flat plates, and consequently the critical stresses are generally higher for a given thickness. These critical stresses may be determined in the same manner as for flat plates, however, by using the following value of equivalent slenderness ratio, expressed in terms of the radius of curvature, R, and the wall thickness, t, both in inches:

$$\text{Equivalent slenderness ratio (Curved Plates)} = 7.1\sqrt{\frac{R}{t}}$$

The above value of equivalent slenderness ratio applies to curved plates used to form complete tubular members. The same value may be used for curved plates, forming less than complete cylinders, provided the edges are adequately stiffened so that failure will not occur by buckling of a free edge.

Seamless aluminum alloy tubes are considerably stronger in resisting local wall buckling than are curved plates of the same radius and thickness in built-up construction, and for this reason the equivalent slenderness ratio for seamless tubes should be lower than that for curved plates. The following value of equivalent slenderness ratio may be used for seamless tubes:

$$\text{Equivalent slenderness ratio (Seamless Tubes)} = 4.7\sqrt{\frac{R}{t}}$$

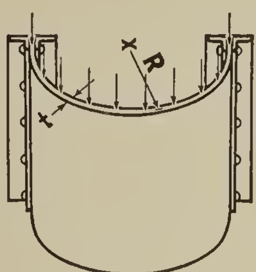
The above values of the equivalent slenderness ratio may be substituted directly in the ultimate column strength formulas for the various aluminum alloys (Table 10) to determine the critical stresses at which curved plates under edge compression will begin to buckle noticeably. The factor of safety to be used with these critical buckling stresses should be about as conservative as that used to determine the allowable working stresses in columns, because buckling of curved plates in compression often results in complete failure of the member. This is particularly true if there are relatively few longitudinal stiffeners used on the curved plate.

Longitudinal stiffeners improve the buckling resistance of curved plates under edge compression, provided they are spaced closer together along the surface of the plate than a distance equal to the radius of curvature. No satisfactory general formulas have been devised for calculating the improvement in buckling resistance produced by various stiffener spacings on curved sheets. For the larger values of $\frac{R}{t}$ with close stiffener spacings, it is sometimes helpful to

calculate the buckling resistance of the sheet between stiffeners as though the sheet were flat, knowing that the actual critical stress is somewhat higher than this value because of the stiffening effect of the curvature.

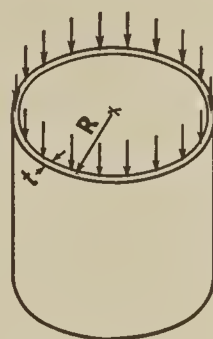
Table 14, below, shows the equivalent slenderness ratios for unstiffened curved plates in edge compression calculated in accordance with the foregoing information.

TABLE 14—VALUES OF EQUIVALENT SLENDERNESS RATIO, $\frac{KL}{r}$, FOR CURVED PLATES AND SEAMLESS TUBES



Curved Plates

$$\frac{KL}{r} = 7.1\sqrt{\frac{R}{t}}$$



Seamless Tubes

$$\frac{KL}{r} = 4.7\sqrt{\frac{R}{t}}$$

$$\frac{R}{t} = \frac{\text{radius of curvature}}{\text{thickness of shell}}$$

Curved plates						Seamless tubes	
$\frac{R}{t}$	$\frac{KL}{r}$	$\frac{R}{t}$	$\frac{KL}{r}$	$\frac{R}{t}$	$\frac{KL}{r}$	$\frac{R}{t}$	$\frac{KL}{r}$
10	23	120	78	500	159	10	15
20	32	140	84	550	167	20	21
30	39	160	90	600	174	30	26
40	45	180	95	650	181	40	30
50	50	200	100	700	188	50	33
60	55	250	112	750	194	60	36
70	59	300	123	800	201	70	39
80	64	350	133	850	207	80	42
90	67	400	142	900	213	90	45
100	71	450	151	1000	225	100	47

These values of equivalent slenderness ratio, $\frac{KL}{r}$, may be used directly in the column formulas (Table 10) to determine the critical compressive stresses at which plates and tubes of various aluminum alloys will buckle.

Bending

In designing beams, girders, and other flexural members, the allowable working stress in tension, to be used for the *net* area of the tension flange, should be the same as the basic allowable tensile stress used for tension members. The basic allowable compressive working stress used for the *gross* area of the compression flange should be the same as the basic allowable compressive working stress used for other compression members. This basic compressive stress, however, can be used only when the laterally unsupported length of the flange is relatively short. The allowable compressive working stress on compression flanges which are supported at longer intervals must be reduced so that a suitable factor of safety is provided against the possibility of a sidewise buckling failure. Such failures occur in compression flanges of beams in much the same manner that column failures occur in members subjected to direct compression. The stress at which such failures occur in a beam flange may be predicted by calculating the column strength of the flange, providing the equivalent radius of gyration of the compression flange is determined in accordance with the following formula:

$$\text{Equivalent radius of gyration of compression flange} = \sqrt{\frac{0.2}{S_c}\sqrt{I_1\left[J(KL)^2 + 13.1\, I_F d^2\right]}},$$

where S_c = section modulus for beam about axis normal to web (compression side) in in.^{3}

I_1 = moment of inertia for beam about principal axis parallel to web in in.^{4}

L = laterally unsupported length of compression flange in inches

K = factor representing end conditions of laterally unsupported length, same as for columns

I_F = moment of inertia of compression flange of beam about axis parallel to web (may be assumed equal to ½ of I_1 in the case of I-shaped members having both flanges alike) in in.^{4}

d = depth of beam in inches

J = torsion factor in in.^{4}

The value of J for structural shapes is included in the tables of elements of sections in this handbook. A reasonably close approximation may readily be obtained for other single-web members by

assuming the cross section of the member to be broken into a series of rectangles. The value of J for the entire member is simply the sum of the individual torsion factors for the separate rectangles as follows:

$$J = \Sigma \tfrac{1}{3} bt^3,$$

where b is the length of each rectangle and t the thickness, both in inches. In the case of a girder built up of a web plate and four angles, the value for the angles may be taken from the tables and added to that for the plate determined as above.

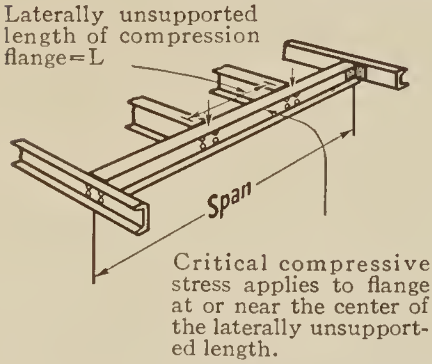
The value of equivalent radius of gyration (page 48) is used with KL, the effective unsupported length of the compression flange, to determine the effective slenderness ratio. This slenderness ratio is then substituted in the column formula for the alloy in question (Table 10) to arrive at the value of critical stress for the compression flange. This critical stress on the compression flange applies to the conditions which exist at or near the center of the unsupported length. Table 15 gives values of effective slenderness ratio for the various Alcoa Aluminum Alloy I-beams, H-beams, and channels.

The equivalent radius of gyration determined according to the foregoing formula is usually greater than the radius of gyration which would be determined for the compression flange in the ordinary manner. Therefore, in most cases, the use of this formula results in higher values of critical compressive stress for beam flanges than would be obtained by considering the flange as a column, using the ordinary radius of gyration. In the case of compact beams, such as I-beams, the difference is often found to be very large so that the use of the more exact method leads to considerable economy of material. In the case of less compact members, such as built-up plate girders, the difference is usually less, and often the radius of gyration of such members, determined in the ordinary manner, approximates very closely the value given by the formula on page 48.

The foregoing discussion of lateral stability of beams applies principally to I-shaped members. The method may be extended without serious error, however, to include channel-shaped members. In all cases it is assumed that the members are adequately supported against tipping or twisting at the point of application of the important loads and reactions. Where such support is not provided, the member should be checked to make sure that any eccentricity of the loads and reactions is taken into account in the calculation of stress. This is particularly true in the case of channel-shaped mem-

(Continued on page 52)

TABLE 15—VALUES OF EQUIVALENT SLENDERNESS RATIO FOR COMPRESSION FLANGES OF BEAMS



$$\text{Equivalent slenderness ratio} = \frac{KL}{r}$$

L = laterally unsupported length of compression flange in inches

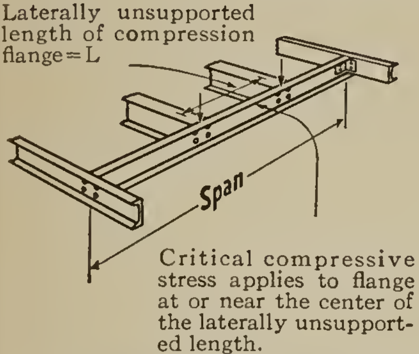
K = factor representing end conditions of laterally unsupported length, same as for columns

r = equivalent radius of gyration of compression flange defined on page 48

I-beams		Equivalent slenderness ratio of compression flange, $\frac{KL}{r}$, for various values of effective unsupported length						
Depth Inches	Weight Lb./ft.	KL = 24 inches	KL = 48 inches	KL = 96 inches	KL = 144 inches	KL = 192 inches	KL = 264 inches	KL = 360 inches
2	0.804	37.8	63.4	96.2	119.7	139.0	163.6	.....
2	1.473	30.5	46.4	67.0	82.4	95.3	111.9	130.7
2½	1.850	27.8	40.8	58.3	71.5	82.7	97.0	113.2
3	2.02	31.3	50.0	73.7	91.0	105.4	123.9	144.8
3	2.67	27.9	43.0	62.6	77.1	89.2	104.7	122.3
4	2.72	30.1	50.3	76.2	94.7	110.0	129.4	151.3
4	3.74	27.1	43.4	64.1	79.3	91.8	107.9	126.1
5	3.53	28.1	48.8	75.9	95.1	110.8	130.6	152.9
5	5.25	25.2	41.2	61.6	76.4	88.6	104.1	121.8
6	4.43	26.2	46.8	74.9	94.7	110.7	130.8	148.2
6	6.13	24.5	42.0	64.7	80.8	94.0	110.7	129.5
7	5.42	24.3	44.5	73.1	93.2	109.4	129.6	152.1
7	7.12	23.4	41.5	65.9	83.0	96.9	114.4	134.1
8	6.53	22.6	42.1	70.6	91.0	107.3	127.5	149.9
8	9.07	21.7	38.9	62.5	79.0	92.4	109.2	128.1
9	7.72	21.1	39.8	68.3	88.9	105.2	125.4	147.8
9	10.68	20.4	37.3	61.1	78.0	91.4	108.3	127.2
10	9.01	19.9	37.8	65.9	86.5	102.9	123.1	145.4
10	12.45	19.3	35.7	59.5	76.4	89.9	106.7	125.5
12	11.31	18.8	36.2	64.5	85.9	102.9	123.8	146.7
12	17.78	17.0	31.8	54.0	69.9	82.6	98.3	115.8
H-beams								
4	4.85	....	33.2	51.7	64.8	75.5	89.0	104.2
5	6.63	....	29.4	48.5	62.0	72.9	86.4	101.5
6	8.04	....	26.0	45.5	59.8	71.2	85.2	100.6
6	9.40	....	25.4	43.6	56.7	67.2	80.2	94.5
8	11.51	....	21.0	39.4	54.5	67.0	82.3	98.9
8	13.32	....	20.8	38.4	52.4	63.8	77.8	92.9

These values of equivalent slenderness ratio, $\frac{KL}{r}$, may be used directly in the column formulas (Table 10) to determine the critical compressive stresses at which beams of the various aluminum alloys will buckle sidewise.

TABLE 15—VALUES OF EQUIVALENT SLENDERNESS RATIO FOR COMPRESSION FLANGES OF BEAMS—Continued



Equivalent slenderness ratio $= \frac{KL}{r}$

L = laterally unsupported length of compression flange in inches

K = factor representing end conditions of laterally unsupported length, same as for columns

r = equivalent radius of gyration of compression flange defined on page 48

Standard channels		Equivalent slenderness ratio of compression flange, $\frac{KL}{r}$, for various values of effective unsupported length						
Depth Inches	Weight Lb./ft.	KL = 24 inches	KL = 48 inches	KL = 96 inches	KL = 144 inches	KL = 192 inches	KL = 264 inches	KL = 360 inches
3	1.46	37.5	56.5	81.4	100.0	115.6	135.7	158.5
3	2.13	30.7	45.1	64.5	79.2	91.5	107.4	125.4
4	1.90	42.9	61.5	87.3	107.0	123.6	145.0	169.3
4	2.58	33.7	51.3	74.2	91.2	105.5	123.8	144.7
5	2.38	37.0	59.9	89.0	110.1	127.6	149.9	175.3
5	4.09	29.9	45.6	66.0	81.2	93.9	110.3	128.8
6	2.91	35.5	59.3	89.8	111.6	129.6	152.4	178.3
6	4.63	30.9	48.9	71.8	88.6	102.6	120.5	140.8
7	3.47	33.8	58.1	89.6	112.0	130.3	153.5	179.7
7	6.13	29.0	46.2	68.1	84.1	97.4	114.4	133.8
8	4.38	31.7	55.6	87.1	109.3	127.4	150.6	175.8
8	6.67	29.0	47.9	72.0	89.3	103.6	121.9	142.6
9	4.74	30.4	54.6	87.6	110.8	129.6	153.2	179.6
9	8.90	26.7	44.1	66.2	82.1	95.2	112.0	131.0
10	5.43	28.8	52.6	86.0	109.5	128.4	152.0	178.5
10	10.67	25.5	42.5	64.2	79.8	92.6	108.9	127.4
12	7.33	25.9	48.2	80.8	104.1	122.7	145.7	171.4
12	12.45	24.2	42.5	66.8	83.9	97.8	115.3	135.1
Special channels								
2	1.253	31.0	45.4	64.8	79.5	91.8	107.7	125.8
2½	1.277	38.3	55.9	79.8	97.9	113.1	132.7	155.0
3	2.30	27.5	42.4	61.7	76.0	87.9	103.2	120.6
3	2.78	25.0	37.6	54.2	66.6	77.0	90.4	105.6
4	3.41	19.9	29.6	42.5	52.2	60.4	70.8	82.8
5	3.19	23.1	38.7	58.5	72.7	84.5	99.4	116.2
5	4.88	24.7	39.1	57.4	70.8	82.0	96.4	112.6
5	5.99	20.5	33.1	49.0	60.6	70.2	82.5	96.5
6	5.94	22.4	37.6	57.0	70.9	82.4	96.9	113.4
6	6.10	19.4	34.5	55.1	69.5	81.2	95.9	112.4
8	6.62	24.1	42.9	68.4	86.3	100.8	119.0	139.5
8	8.09	19.4	35.9	58.0	73.5	86.0	101.8	119.4
10	8.84	20.8	38.4	63.7	81.6	96.0	113.8	133.7
10	10.34	20.3	36.8	59.9	76.2	89.3	105.6	124.0

These values of equivalent slenderness ratio, $\frac{KL}{r}$, may be used directly in the column formulas (Table 10) to determine the critical compressive stresses at which beams of the various aluminum alloys will buckle sidewise.

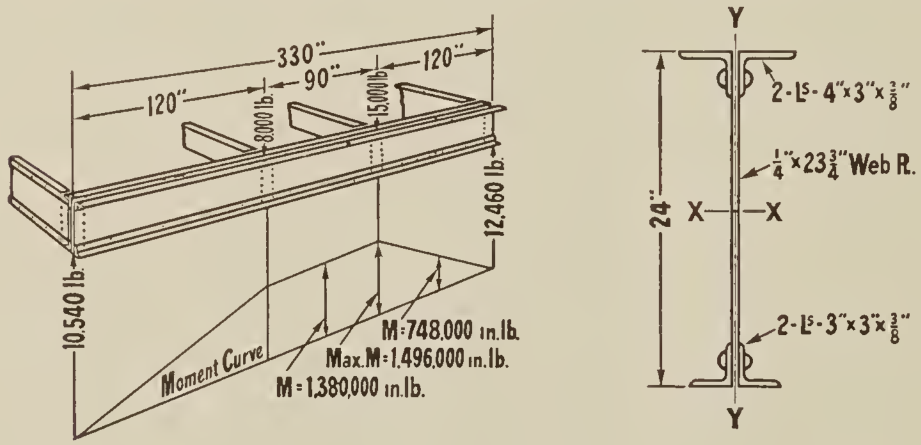
bers where the loading is likely to be eccentric with respect to the shear center, thereby introducing a definite torque on the member in addition to the bending. In all such cases involving combined torsion and bending, and in cases of unsymmetrical bending, the foregoing method of analysis of lateral stability does not apply. It is usually sufficient in such cases to calculate the maximum combined flange stress and to keep this stress within the safe allowable working stress limits of the flange material.

Double-web box girders, because of their tube-like cross section, are very much stiffer in torsion than single-web girders of comparable size. For the depth-width ratios ordinarily encountered in design, double-web box girders are so stiff in torsion that lateral buckling failures of the compression flange are of no importance in structural design, and therefore it is not necessary to make any reduction in allowable stress because of the slenderness ratio or length-width ratio of the flange. The allowable stress on the compression flange of such members is usually restricted by the possibility of local buckling of the compression cover plate.

Example 5. Check flange stress in plate girder for loading shown in sketch, using the following allowable working stresses, 17S-T alloy:

Tension on net area, factor of safety of 2 on guaranteed minimum yield strength, $= \frac{30{,}000}{2} = 15{,}000$ lb./sq. in.

Compression on gross area, factor of safety of 2.5 on critical stress, with upper limiting value equal to tensile allowable stress = 15,000 lb./sq. in.



S (compression) = 125 in.^{3}

S (tension) = 114 in.^{3}

$I_Y = 25.0$ in.^{4}

$J = 0.580$ in.^{4}

$I_F = 17.4$ in.^{4}

These section elements are taken from page 141.

Calculated maximum tensile stress on net area (page 141)
$= \frac{1,496,000}{114} \times 1.13 = 14,800$ lb./sq. in. (less than 15,000, therefore satisfactory).

Calculated maximum compressive stress on gross area
$= \frac{1,496,000}{125} = 12,000$ lb./sq. in.

This maximum stress occurs at a point of lateral support where no lateral bending can occur, therefore it is checked against the upper limiting compressive stress, 15,000 lb./sq. in. and found to be satisfactory. (For final check, see Example 6.)

Calculated compressive stress at center of 90″ unsupported length
$= \frac{1,380,000}{125} = 11,000$ lb./sq. in.

Equivalent radius of gyration, assuming K = 0.8 (page 48),

$$= \sqrt{\frac{0.2}{125}\sqrt{25.0\left[0.580\ (0.8 \times 90)^2 + 13.1 \times 17.4 \times \overline{24}^2\right]}} = 1.71''.$$

Equivalent slenderness ratio $= \frac{0.8 \times 90}{1.71} = 42.$

Critical flange stress (Table 10, 17S-T alloy) $= 43,800 - 350 \times 42$
$= 29,100$ lb./sq. in.

Allowable working stress $= \frac{29,100}{2.5} = 11,600$ lb./sq. in.

This allowable stress is greater than the calculated stress, 11,000 lb./sq. in., therefore the flange is safe for the 90″ unsupported length.

Calculated compressive stress at center of 120″ unsupported length
$= \frac{748,000}{125} = 5980$ lb./sq. in.

Equivalent radius of gyration, assuming K = 0.9,

$$= \sqrt{\frac{0.2}{125}\sqrt{25.0\left[0.580\ (0.9 \times 120)^2 + 13.1 \times 17.4 \times \overline{24}^2\right]}} = 1.72''.$$

Equivalent slenderness ratio $= \frac{0.9 \times 120}{1.72} = 63$

Critical flange stress $= 43,800 - 350 \times 63 = 21,800$ lb./sq. in.

Allowable working stress $= \frac{21,800}{2.5} = 8720$ lb./sq. in.

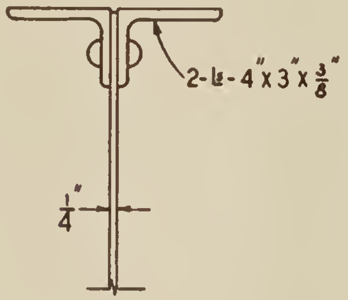
This allowable stress is greater than the calculated stress, 5980 lb./sq. in., therefore the flange is safe for the 120″ unsupported length.

Local Buckling of Compression Flanges

The compression flanges of beams and girders may fail by local buckling of some component part if relatively thin material is used in the construction of the flange. In order to design such members safely and economically, it is necessary to check the allowable compressive working stress not only for stability of the flange as a

whole, but also for local buckling, the final allowable working stress for the flange being the lower of the values arrived at in this manner. The critical buckling stresses for flat plates forming parts of the compression flanges of beams may be determined in the same manner as already given for flat plates in edge compression. Suitable factors of safety should be used with these critical stresses.

Example 6. Check the plate girder used in Example 5 to see if local buckling of the outstanding legs of the 4″×3″×⅜″ compression flange angles controls the design.



$$\frac{b}{t} \text{ for 4″ leg} = \frac{4.00-0.375}{0.375} = 9.7$$

The equivalent slenderness ratio for this member is between the following (page 41):

$5.1\,\frac{b}{t}$ (one edge simply supported, other edge free)

$2.9\,\frac{b}{t}$ (one edge built in, other edge free)

This flange is nearer the second condition, the edge of the 4″ leg being restrained not only by the 3″ leg but also by the web.

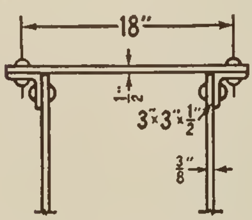
Assume equivalent slenderness ratio $= 3.5\,\frac{b}{t} = 3.5 \times 9.7 = 34$

Critical stress (Table 10, 17S-T alloy) $= 43{,}800 - 350 \times 34$
$= 31{,}900$ lb./sq. in.

Allowable working stress $= \frac{31{,}900}{2.5} = 12{,}800$ lb./sq. in.

This allowable stress is greater than the maximum calculated stress, 12,000 lb./sq. in. (Example 5), therefore local buckling of the outstanding leg does not control the design of the compression flange.

Example 7. Determine allowable working stress for compression flange of box girder shown in sketch, using a factor of safety of 2 on the critical buckling stress of the cover plate, 53S-T alloy,



$$\frac{b}{t} = \frac{18}{½} = 36$$

The equivalent slenderness ratio lies between $1.65\,\frac{b}{t}$ and $1.25\,\frac{b}{t}$ (edges simply supported and edges fixed, page 41).

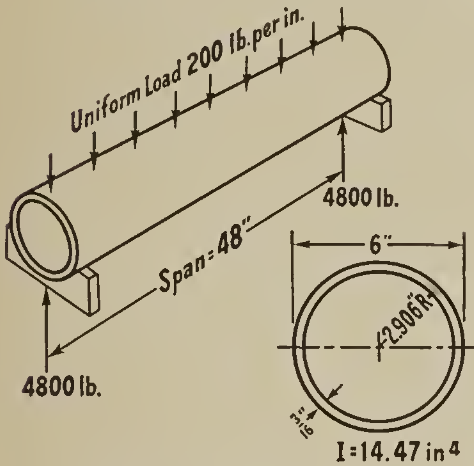
Assume equivalent slenderness ratio $= 1.5\,\frac{b}{t} = 1.5 \times 36 = 54.$

Critical stress (Table 10, 53S-T alloy) $= 38{,}400 - 287 \times 54$
$= 22{,}900$ lb./sq. in.

Allowable working stress $= \frac{22{,}900}{2} = 11{,}450$ lb./sq. in.

Tubular beams made of curved plates or thin seamless tubes should be checked for local compression buckling failures. The critical compressive stresses may be taken 25 per cent greater than those already given for similar members in direct compression.

Example 8. Check seamless tubular beam to see if compressive stress is safe for 53S-T alloy, using factor of safety of 3 on critical buckling stress.



$$\text{Max. moment} = \frac{200 \times \overline{48}^2}{8} = 57{,}600 \text{ in.-lb.}$$

Calculated compressive stress

$$= \frac{57{,}600 \times 3.0}{14.47} = 11{,}900 \text{ lb./sq. in.}$$

Ratio of radius to thickness

$$= \frac{R}{t} = \frac{2.906}{0.1875} = 15.5$$

Equivalent slenderness ratio

$$= 4.7\sqrt{15.5} = 19 \text{ (page 46).}$$

Critical stress assuming edge compression (Table 10, 53S-T alloy) $= 38{,}400 - 287 \times 19 = 32{,}900$ lb./sq. in.

Critical stress for bending $= 32{,}900 \times 1.25 = 41{,}100$ lb./sq. in.

$$\text{Allowable working stress} = \frac{41{,}100}{3} = 13{,}700 \text{ lb./sq. in.}$$

This allowable stress exceeds the calculated compressive stress, 11,900 lb./sq. in., therefore the tube is safe.

Compression Buckling of Thin Webs

The webs of beams and girders are subjected to a horizontal compressive stress varying from zero at the neutral axis to a maximum at the compression flange. Thin webs may tend to buckle under the influence of these compressive stresses the same as other flat plates subjected to edge compression. To determine the critical stress, the following value of equivalent slenderness ratio should be used with the column formula for the material in question (Table 10):

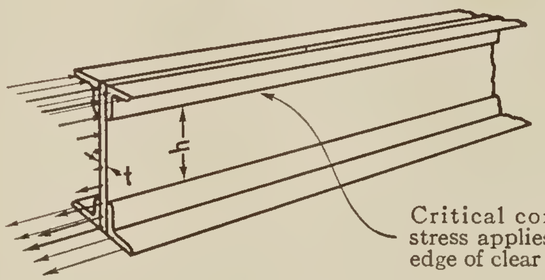
$$\text{Equivalent slenderness ratio} = 0.67\frac{h}{t},$$

where h = clear height of web in inches
t = thickness of web in inches

The critical stress found in this manner applies to the condition which exists at the compression edge of the clear height of the web, adjacent to the compression flange. Table 16, page 56, gives values of equivalent slenderness ratio for various ratios of clear height to thickness.

Since compression buckling of thin webs does not often lead to complete failure of the member, the factor of safety to be used with the foregoing critical stresses need not be as conservative as those used in determining the more important allowable working stresses. Appearance is probably the most important item to be considered in arriving at a suitable factor of safety. In many instances the factor of safety may be allowed to approach very close to unity. Compression buckling of the web will control the design of the compression flange only in the case of very thin-web girders. More often the allowable compressive flange stress will be restricted by lateral buckling of the flange or some other consideration.

TABLE 16—EQUIVALENT SLENDERNESS RATIOS, $\frac{KL}{r}$, FOR WEBS OF BEAMS



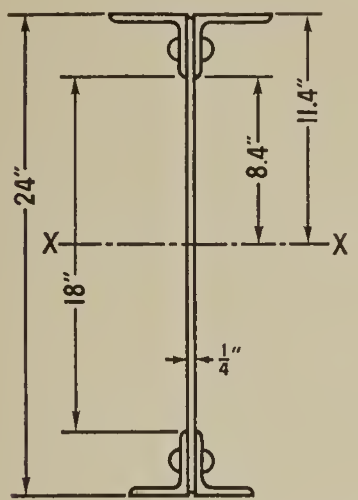
$$\frac{h}{t} = \frac{\text{clear depth of web}}{\text{thickness of web}}$$

$$\text{Equivalent slenderness ratio} = 0.67\,\frac{h}{t}$$

$\frac{h}{t}$	$\frac{KL}{r}$	$\frac{h}{t}$	$\frac{KL}{r}$
10	7	120	81
20	13	140	94
30	20	160	107
40	27	180	121
50	34	200	134
60	40	220	148
70	47	240	161
80	54	260	174
90	60	280	188
100	67	300	201

These values of equivalent slenderness ratio, $\frac{KL}{r}$, may be used directly in the column formulas (Table 10) to determine the critical compressive stresses at which plates of various aluminum alloys will buckle.

Example 9. Check the plate girder used in Example 5 to see if compression buckling of the web controls the design.



Calculated maximum compressive stress at top of clear height of web

$$= 12{,}000 \times \frac{8.4}{11.4} = 8800 \text{ lb./sq. in.}$$

Equivalent slenderness ratio of web (page 55) $= 0.67 \times \frac{h}{t} = 0.67 \times \frac{18}{0.25} = 48$

Critical stress (Table 10, 17S-T alloy) $= 43{,}800 - 350 \times 48 = 27{,}000$ lb./sq. in.

Allowable working stress (factor of safety of 2.5) $= \frac{27{,}000}{2.5} = 10{,}800$ lb./sq. in.

This allowable stress is greater than the calculated stress, 8800 lb./sq. in., therefore compression buckling of web does not control the design.

Combined Bending and Direct Compression

When a short compact member is subjected to combined bending and direct compression, the basic allowable working stresses in tension and compression apply, because no stability problem is involved. The same is true for longer members, provided the maximum stresses occur at or near the ends of the unsupported length. A longer member in which the maximum stresses occur at or near the center of the unsupported length, however, will function partly as a beam and partly as a column, and the allowable compressive working stress must be selected accordingly. An allowable bending stress selected in accordance with the following formula will give a factor of safety in combined bending and compression which is consistent with those used separately in bending and compression.

Maximum bending stress (compression) on extreme fiber, which may be permitted at or near center of unsupported length, in addition to direct compression, $\frac{P}{A}$, $= \left(f_b - \frac{P}{A}\right)\left(1 - \frac{\frac{P}{A}}{f_c}\right)$,

where $\frac{P}{A}$ = average compressive stress on cross section of member produced by column load in lb./sq. in.

f_b = allowable compressive working stress for member considered as a beam in lb./sq. in.

f_c = allowable working stress for member considered as a column tending to fail in plane of bending forces in lb./sq. in.

This formula for allowable bending stress is derived on the assumption that failure of the member will occur by bending in the plane of the bending forces, which is always the case if this plane coincides with the plane of least stiffness of the member. Members having bending forces applied in the plane of their greatest stiffness, however, may tend to fail by sidewise bending at right angles to the plane of the bending forces. To take care of this contingency, it is necessary to use the following additional formula for allowable bending stress:

Maximum bending stress (compression) on extreme fiber, which may be permitted at or near center of unsupported length, in addition to direct compression, $\frac{P}{A}$,

$$= f_b \sqrt{1 - \frac{\frac{P}{A}}{f_c'}}$$

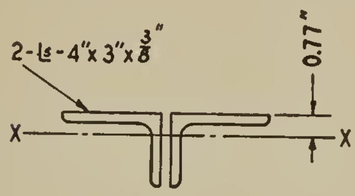
where f_c' = allowable working stress for member considered as a column tending to fail in direction normal to plane of bending forces in lb./sq. in.

f_b and $\frac{P}{A}$ are as previously defined.

For a member under combined loading, in which the bending forces are applied in the plane of greatest stiffness, it is necessary to apply each of the two foregoing formulas, and select the lower of the two values as the maximum bending stress to be permitted in addition to the direct compression, $\frac{P}{A}$.

In designing members for combined bending and direct compression, using the above formulas, it is rarely possible to determine the proper size of the member directly. The design procedure involves trial and error methods in which a member is selected and then checked to see if the calculated bending stress is within the allowable limits. It is always well to check the member finally selected for the possibility of column failure alone, about two or more axes. Obviously, the member selected for combined bending and compression should not be weaker than the one which would be selected for either loading considered separately.

Example 10. Check the chord used in Example 1 to see if, in addition to the 45,000 lb. axial load, it can safely carry a vertical bending load of 500 lb. concentrated at the center of one of the 60″ spans; factor of safety to remain 2.5, same as in Example 1.



I = 3.72 in^4
A = 4.98 sq.in.

Check for axial load alone.
From Example 1 it is evident that the member is safe for column load alone because the calculated direct compression, $\frac{P}{A}$, is only 9040 lb./sq. in. compared to an allowable column stress, f_c, of 9680 lb./sq. in.

Check for beam loading alone.
Bending moment at center of unsupported length, assuming K = 0.8 same as in Example 1,

$$M = \frac{500 \times 0.8 \times 60}{4} = 6000 \text{ in.-lb.}$$

Calculated bending stress (compression),

$$\frac{Mc}{I} = \frac{6000 \times 0.77}{3.72} = 1240 \text{ lb./sq. in.}$$

Allowable working stress for member as a beam (compression flange),
$f_b = 11{,}360$ lb./sq. in. (factor of safety of 2.5 against buckling of outstanding leg, see Example 2a).

Member is therefore safe for bending alone.

Check for combined loading.
Maximum bending stress (compression) which may be permitted in addition to $\frac{P}{A}$,

$$= \left(f_b - \frac{P}{A}\right)\left(1 - \frac{\frac{P}{A}}{f_c}\right) = (11{,}360 - 9040)\left(1 - \frac{9040}{9680}\right) = 153 \text{ lb./sq. in.}$$

Since this allowable stress is less than the calculated stress, 1240 lb./sq. in., a larger member would be needed to avoid reducing the factor of safety.

Example 10a. Recheck member above using factor of safety of 2.0 instead of 2.5.

New value of $f_b = 11{,}360 \times \frac{2.5}{2.0} = 14{,}200$ lb./sq. in.

New value of $f_c = 9680 \times \frac{2.5}{2.0} = 12{,}100$ lb./sq. in.

New value of maximum bending stress which may be permitted in addition to $\frac{P}{A}$

$$= (14{,}200 - 9040)\left(1 - \frac{9040}{12{,}100}\right) = 1310 \text{ lb./sq. in.}$$

Since this allowable bending stress is greater than the calculated bending stress, 1240 lb./sq. in., the factor of safety against failure under combined loading is greater than 2.0.

Shear

The ultimate shear strengths and shear yield strengths of the various Alcoa Aluminum Alloys are given in Table 3, page 23. In arriving at suitable allowable working stresses in shear, both shearing yield and shearing ultimate should be taken into account and factors of safety comparable with those used in selecting allowable tensile working stresses should be employed. While it is common practice to apply the working stress in shear to the gross section of members, the possibility of shearing along the net section should not be overlooked, and the factor of safety to be used will depend somewhat on which way the allowable stress is to be used in design.

Shear Buckling of Flat Plates

When relatively thin flat plates, such as the webs of girders, are subjected to shearing forces, they almost always buckle before the shearing yield strength of the material is reached. The critical shear buckling stress for such flat sheets supported along two edges, as in the case of the web of a plate girder without stiffeners, may be calculated by means of the following formula:

$$\text{Critical shear buckling stress} = \frac{51{,}000{,}000}{\left(\frac{b}{t}\right)^2},$$

where t = thickness of plate in inches
b = unsupported width of plate in inches

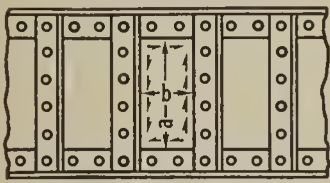
When a flat plate is supported on four sides, forming a rectangular panel in which the longer dimension, a, is less than four times the shorter dimension, b, the critical shear buckling stress is appreciably greater than in the foregoing case, and the formula may be written as follows:

$$\text{Critical shear buckling stress} = \frac{51{,}000{,}000}{\left(\frac{b}{t}\right)^2}\left[1+0.75\left(\frac{b}{a}\right)^2\right]$$

The above formulas are the same for all aluminum alloys, because they are based entirely on the modulus of elasticity of the material. The shearing yield strength of the material, taken from Table 3,

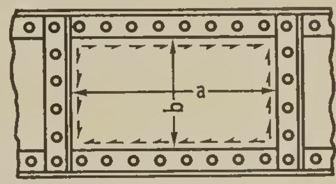
TABLE 17—CRITICAL SHEAR BUCKLING STRESSES FOR RECTANGULAR PANELS OF FLAT PLATE

$$\text{Critical stress} = \frac{51{,}000{,}000}{\left(\frac{b}{t}\right)^2}\left[1+0.75\left(\frac{b}{a}\right)^2\right]$$



$$\frac{b}{t} = \frac{\text{short dimension of panel}}{\text{thickness of plate}}$$

$$\frac{b}{a} = \frac{\text{short dimension of panel}}{\text{long dimension of panel}}$$



These values of critical stress apply to all the alloys, but the upper limiting value for any particular alloy is the value of the shearing yield strength given in Table 3.

$\frac{b}{t}$	$\frac{b}{a}=0$	$\frac{b}{a}=0.4$	$\frac{b}{a}=0.5$	$\frac{b}{a}=0.6$	$\frac{b}{a}=0.7$	$\frac{b}{a}=0.8$	$\frac{b}{a}=0.9$	$\frac{b}{a}=1.0$
40	31,880	35,700	37,850	40,480	43,590	47,180	51,240	55,780
42	28,910	32,380	34,330	36,720	39,540	42,790	46,480	50,600
44	26,340	29,500	31,280	33,460	36,020	38,990	42,350	46,100
46	24,100	26,990	28,620	30,610	32,960	35,670	38,740	42,180
48	22,140	24,790	26,290	28,110	30,270	32,760	35,580	38,740
50	20,400	22,850	24,230	25,910	27,900	30,190	32,790	35,700
52	18,860	21,120	22,400	23,950	25,790	27,910	30,320	33,010
54	17,490	19,590	20,770	22,210	23,920	25,890	28,120	30,610
56	16,260	18,220	19,310	20,650	22,240	24,070	26,140	28,460
58	15,160	16,980	18,000	19,250	20,730	22,440	24,370	26,530
60	14,170	15,870	16,820	17,990	19,370	20,970	22,770	24,790
62	13,270	14,860	15,760	16,850	18,140	19,640	21,330	23,220
64	12,450	13,950	14,790	15,810	17,030	18,430	20,020	21,790
66	11,710	13,110	13,900	14,870	16,010	17,330	18,820	20,490
68	11,030	12,350	13,100	14,010	15,080	16,320	17,730	19,300
70	10,410	11,660	12,360	13,220	14,230	15,400	16,730	18,210
75	9,070	10,160	10,770	11,520	12,400	13,420	14,580	15,870
80	7,970	8,930	9,460	10,120	10,900	11,790	12,810	13,950
85	7,060	7,910	8,380	8,970	9,650	10,450	11,350	12,350
90	6,300	7,050	7,480	8,000	8,610	9,320	10,120	11,020
100	5,100	5,710	6,060	6,480	6,970	7,550	8,200	8,930
110	4,220	4,720	5,010	5,350	5,760	6,240	6,780	7,380
120	3,540	3,970	4,210	4,500	4,840	5,240	5,690	6,200
130	3,020	3,380	3,580	3,830	4,130	4,470	4,850	5,280
140	2,600	2,910	3,090	3,310	3,560	3,850	4,180	4,550
150	2,270	2,540	2,690	2,880	3,100	3,360	3,640	3,970
175	1,670	1,870	1,980	2,120	2,280	2,460	2,680	2,910
200	1,280	1,430	1,510	1,620	1,740	1,890	2,050	2,230
250	820	910	970	1,040	1,120	1,210	1,310	1,430
300	570	640	670	720	780	840	910	990

should be used as the upper limiting value of critical stress for each alloy. Table 17, page 61, gives calculated values for critical shear buckling stress for flat plates based on the foregoing formulas.

The factor of safety, to be used with the foregoing values in arriving at allowable working stresses for shear on flat plates supported on only two edges, generally should be about the same as that used in selecting allowable working stresses for columns, because a buckling failure of such a plate will often result in complete collapse of the structure. A smaller factor of safety may be used in the case of flat plates supported on all four edges, because a buckling failure of such a plate does not necessarily result in collapse if the edge stiffeners are stiff enough to function as compression struts. For example, if the thin web of a well-stiffened plate girder buckles under high shearing stresses, it will continue to transmit diagonal tension, and the stiffeners will begin to function as compression struts between the two flanges so that the girder will withstand considerable additional load, functioning almost as though it were a truss. In some fields of construction, thin-web girders are actually designed to transmit loads in this manner, buckling being entirely ignored in the interests of eliminating as much web material as possible.

It should be clear from the foregoing that the factor of safety to be used with the critical shear stresses on well-stiffened rectangular flat plates will be determined largely by the importance which is attached to the unsightly appearance of buckles in the sheet. Such flat sheets often buckle gradually rather than suddenly, so that slight buckling is sometimes visible at stresses as low as one half of the critical buckling stress. Therefore, where a high degree of flatness must be maintained even under maximum loading conditions, a generous factor of safety should be used in arriving at allowable shearing working stresses.

Example 11. Check girder used in Example 5 to see if web plate will resist shear buckling with a factor of safety of 2.5.

Maximum total shear on web, $V = 12{,}460$ lb.

Gross web area, $A = 23.75 \times 0.25 = 5.94$ sq. in.

Calculated average shear stress on web,

$$\frac{V}{A} = \frac{12{,}460}{5.94} = 2100 \text{ lb./sq. in.}$$

Minimum dimension of end panel of web, $b = 18''$ (clear height)

Other dimension of end panel of web, $a = 116''$ (approximate)

$$\frac{b}{t} = \frac{18}{0.25} = 72 \qquad \frac{b}{a} = \frac{18}{116} = 0.155$$

$$\text{Critical stress} = \frac{51{,}000{,}000}{\overline{72}^2}\left[1+0.75\ (0.155)^2\right]$$

$$=9850\ [1.018] = 10{,}000\ \text{lb./sq. in.}$$

$$\text{Allowable working stress} = \frac{10{,}000}{2.5} = 4000\ \text{lb./sq. in.}$$

This allowable stress is considerably greater than the calculated stress, 2100 lb./sq. in., therefore the web easily resists shear buckling.

Note.—If calculated stress had exceeded allowable stress, web could have been increased in thickness or web stiffeners could have been added to break up panel into rectangles having larger ratio of $\frac{b}{a}$.

Example 11a. Calculate the maximum shear stress on web of girder used in Example 11 to see if it is enough larger than average shear stress to make any difference in the design.

Area of cross section above neutral axis (page 141)
$=4.98+(11.4-0.125)\ 0.25=4.98+2.82=7.80$ sq. in.

Statical moment of this area about the neutral axis,
$Q=4.98\times10.63+2.82\times5.64=69$ in.^{3}

Calculated maximum shear stress on web,

$$\frac{VQ}{It}=\frac{12{,}460\times 69}{1430\times 0.25}=2400\ \text{lb./sq. in.}$$

This stress is 14% greater than the average stress, 2100 lb./sq. in., calculated in Example 11, but is still well under the allowable working stress, 4000 lb./sq. in.

Shear Buckling of Curved Plates

Thin-walled cylinders in transverse bending or torsion are likely to fail by buckling in shear if the shear stresses exceed certain critical values. The critical stress at which such buckling will occur may be found by the following formula:

$$\text{Critical shear stress} = \frac{2{,}600{,}000}{\left(\frac{R}{t}\right)^{3/2}},$$

where R = radius of curvature in inches
t = thickness of shell in inches

This formula applies for all curved plates in shear if no stiffeners are used. When stiffeners are used, either longitudinal or circumferential, the formula for determining the allowable critical stress becomes more complex and reference should be made to technical literature covering this subject. Table 18, page 64, gives values of critical shear buckling stress for various $\frac{R}{t}$ ratios on unstiffened curved plate. These values are the same for all Alcoa Aluminum Alloys, the upper limiting value in the case of each alloy being the shearing yield strength of the material taken from Table 3, page 23.

TABLE 18—CRITICAL SHEAR BUCKLING STRESSES FOR CURVED PLATES

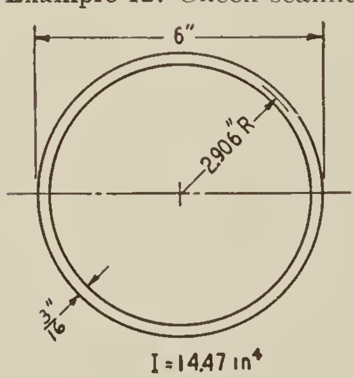
$$\text{Critical shear stress} = \frac{2{,}600{,}000}{\left(\frac{R}{t}\right)^{3/2}}$$

$$\frac{R}{t} = \frac{\text{radius of curvature}}{\text{thickness of plate}}$$

These values of critical stress apply to all the alloys, but the upper limiting value for any particular alloy is the value of the shearing yield strength given in Table 3.

$\frac{R}{t}$	Critical Stress	$\frac{R}{t}$	Critical Stress
18	34,050	45	8,610
20	29,070	50	7,350
22	25,200	55	6,370
24	22,110	60	5,590
26	19,610	65	4,960
28	17,550	70	4,440
30	15,820	75	4,000
32	14,360	80	3,630
34	13,110	85	3,320
36	12,040	90	3,050
38	11,100	95	2,810
40	10,280	100	2,600

Example 12. Check seamless tube used in Example 8 to see if shear buckling controls design.



Maximum shear, V = 4800 lb.

Calculated maximum shear stress (see Example 11a),

$$= \frac{VQ}{I(2t)} = \frac{V(2R^2t)}{I(2t)}$$

$$= \frac{4800[2(2.906)^2 \times 0.1875]}{14.47(2 \times 0.1875)}$$

$$= 2800 \text{ lb./sq. in.}$$

$$\text{Critical shear stress} = \frac{2{,}600{,}000}{\left(\frac{R}{t}\right)^{3/2}} = \frac{2{,}600{,}000}{\left(\frac{2.906}{0.1875}\right)^{3/2}} = 42{,}600 \text{ lb./sq. in.}$$

This value of critical stress exceeds the shear yield strength of the material, 20,000 lb./sq. in., therefore the latter figure becomes the critical stress instead of the former.

$$\text{Allowable working stress} = \frac{20{,}000}{3} = 6700 \text{ lb./sq. in.}$$

This allowable stress is greater than the calculated stress, 2800 lb./sq. in., therefore shear buckling does not control the design.

Rivets in Shear and Bearing

In selecting allowable working stresses for shear on rivets, it is well to remember that the strength of a driven rivet is influenced considerably by the manner of heating and driving. For this reason, it is not always safe to assume that the shear strength of a driven rivet will be equivalent to the typical shear strength of the alloy in the rivet. Table 19, page 66, gives average shear strength values obtained on tests of driven rivets of steel and aluminum alloy, and these rather than the shear strengths in Table 3 should be used in arriving at allowable working stresses for rivets in shear.

Tests made on rivets and tight-fitting pins indicate that the first measurable permanent set in a hole occurs when the average stress on the projected area of the hole reaches a value about equal to the tensile strength of the material. Therefore, the tensile strengths of the materials given in Table 3 may be considered as yield strengths in bearing. The stress at which bearing failures occur has been found to be a function of the edge distance in the direction of stressing. When this edge distance, measured from the center of the hole, is equal to two times the hole diameter, the ultimate bearing strength of various alloys has been found to equal about 1.8 times the tensile strength of the material. This ultimate bearing strength may be used when the edge distance in the direction of stressing is at least two times the diameter of the hole. For smaller edge distances the ultimate bearing strength should be reduced proportionately. Table 20, page 67, gives typical bearing yield strengths and bearing ultimate strengths for plates and shapes of the various alloys.

The allowable working stresses in bearing should have about the same relation to the bearing yield and bearing ultimate that the

basic tensile working stress has to the tensile yield and tensile ultimate. There is such a wide spread between the yield and ultimate in bearing that ordinarily only the yield need be considered in selecting the basic working stress except in the case of some of the smaller edge distances.

Sometimes it is desirable to use a rivet which is softer than the material through which it is driven. In such cases the bearing values of the rivet rather than the bearing strength of the plate should govern the design. Table 19, below, gives a list of bearing strengths of driven rivets of various Alcoa Aluminum Alloys. The values given for driven rivets are believed to be representative of the material in driven rivets, and the use of allowable working stresses in bearing, based on these values, will insure a satisfactory factor of safety against early failure which might result from ignoring the difference in hardness between the rivet and the adjacent materials.

TABLE 19—ULTIMATE SHEARING AND BEARING STRENGTHS OF DRIVEN RIVETS

Rivet	Shear strength Lb./sq. in.	Bearing strength* Lb./sq. in.
17S-T, driven cold, immediately after quench†	35,000	105,000
17S, driven at 950°F.†	34,000	102,000
53S-W, driven cold, as-received	25,000	59,000
53S, driven at 970°F.†	18,000	53,000
Steel, driven cold or hot	45,000	135,000

*These values are to be used only when they are less than the corresponding value for the material in which the rivets are used.

†Immediately after driving, the shear strengths of these rivets are about 75 per cent of the values shown. On standing at ordinary temperatures the rivets age harden to develop full strength, this action being complete in about 4 days.

Impact

The foregoing discussion of the strength, critical stresses, and allowable working stresses is based on the assumption that all loadings are static. The entire discussion may be extended to include ordinary live load conditions, however, if a suitable impact factor is used to represent dynamic effects of moving loads. Unusual dynamic effects such as uncushioned shock loads should be treated

TABLE 20—BEARING STRENGTHS OF ALUMINUM ALLOY PLATES AND SHAPES REPRESENTATIVE OF MATERIAL HAVING THE TYPICAL PROPERTIES SHOWN IN TABLE 3

Alloy	Bearing yield strength Lb./sq. in.	Bearing ultimate[1] strength Lb./sq. in.	Alloy	Bearing yield strength Lb./sq. in.	Bearing ultimate[1] strength Lb./sq. in.
3S-O	16,000	28,000	17S-T	60,000	108,000
3S-¼H	18,000	32,000	27S-T[2]	65,000	117,000
3S-½H	21,000	38,000			
3S-¾H	25,000	45,000	52S-O	29,000	52,000
3S-H	29,000	52,000	52S-¼H	34,000	61,000
			52S-½H	37,000	67,000
4S-O	26,000	46,000	52S-¾H	39,000	70,000
4S-¼H	31,000	56,000	52S-H	41,000	74,000
4S-½H	34,000	61,000			
4S-¾H	37,000	67,000	53S-W	33,000	59,000
4S-H	40,000	72,000	53S-T	39,000	70,000

[1]These values should be used only when the edge distance measured from the center of rivet hole in the direction of stressing is equal to or greater than twice the diameter of the rivet hole. For smaller edge distances values should be reduced proportionately.

[2]Special purpose alloy. See page 19.

somewhat more carefully than the more normal loading conditions, and in such cases it is not always satisfactory to use a conventional assumed impact factor as an allowance for impact. A more thorough analysis, involving a study of the dissipation of the energy of the moving loads, is often the only safe procedure when designing for unusual conditions of impact in structural design.

Repeated Stress

When stresses are repeatedly applied to any metal for a large number of cycles, failure may occur by fatigue action even though the stresses represent an adequate factor of safety against steady stress. Fatigue action on ordinary structures occurs very rarely and usually only because there exists at some critical point a highly concentrated stress, considerably larger in magnitude than is indicated by ordinary design calculations. A study of the fatigue data in Table 5, page 25, and Table 6, page 26, indicates that even after making some allowance for such concentrated stresses, the Alcoa Aluminum

Alloys still have a margin of safety against fatigue action. In the lower strength aluminum alloys, the allowable working stresses are almost never selected high enough to cause any concern about fatigue. In the higher strength aluminum alloys, however, allowable working stresses may be high enough to make it advisable to consider the possibility of fatigue action.

In studying repeated stress, it should be remembered that the maximum loadings assumed in ordinary structural design are usually much more severe than those which occur regularly in service. Furthermore, combinations of loadings are often assumed which occur very infrequently. An intelligent study of fatigue action in any structure usually involves a separate analysis of the stresses, using live loading conditions quite different from the maximum loadings assumed in the ordinary design. Ordinarily, dead-load stresses are not repeated. The live loads produce stress cycles which are superimposed on the steady dead-load stresses.

In using the fatigue data in Tables 5 and 6, it should be remembered that these data are obtained on polished specimens in which stress concentrations are purposely minimized. Suitable allowance must always be made for re-entrant corners, notches, holes, joints, and all other conditions which may produce localized high stresses. These localized high stresses, which have almost no effect on the static strength of the members, are of great importance in studying the effect of repeated stress. Unfortunately, little information of a practical character is available for estimating the magnitude of such concentrations, but it is well to remember at least one commonly used example of stress concentration: that which exists at the edge of a round hole in a wide plate under uniform tensile load. Under these conditions the stress at the edge of the hole is three times the average stress on the net section of the plate.

DESIGN CONSIDERATIONS FOR ALUMINUM ALLOY STRUCTURES

THE PREVIOUS CHAPTER dealt with the selection of allowable working stresses for use in the design of aluminum alloy structures. The allowable working stresses are the controlling factor in the design of most of the members in a structure, but the final selection of the size and shape of the various members, as well as their arrangement, will often be influenced by other considerations. In this chapter, an attempt will be made to present information which will assist the designer in arriving at a well-balanced, economical design.

In many fields of structural design, there have been developed sets of limitations on the size and shape of members. For example, it is sometimes specified that the slenderness ratio of columns shall not exceed 200 or that the unsupported width of plates shall be not greater than 40 times the thickness. In different fields of design, such limitations vary considerably, and, since aluminum alloys are used in numerous types of construction, no attempt will be made in this book to establish such a set of limitations.

Freedom from the conventional limitations on size of parts should assist the designer in arriving at minimum weight of metal in the finished structure, a goal which is usually of primary importance in the design of aluminum alloy structures. On the other hand, freedom from such restrictions places an obligation on the designer to be especially careful in considering all loadings, both intentional and accidental, which the members may be called upon to resist in service. For example, almost any horizontal member in a structure may be called upon to support a man's weight at mid-span. A careful review of the conditions which will exist during fabrication and erection, as well as during the useful life of a structure, will often suggest other loadings for which members, particularly light bracing members, should be checked. A check of the strength of members on such a basis should accomplish the same purpose as the arbitrary size limitations and should do so with a net gain in both economy and safety.

Deflection

One of the most common limitations in structural design is that applying to deflections, and, since the aluminum alloys have a relatively low modulus of elasticity, such restrictions may require some special considerations in design. In all cases where deflection seems to be a controlling factor in the design, the reasons for limiting the deflection should be carefully examined. The selection of allowable deflections is often just as important as the selection of allowable working stresses.

The deflections of aluminum alloy members may be calculated from the conventional deflection formulas provided the correct value of modulus of elasticity, 10,300,000 lb. per sq. in., is used.

For design purposes, particularly in the preliminary stages of a design, it is often unnecessary to strive for a high degree of precision. In such cases the following formula for approximating the deflection at mid-span for aluminum alloy beams of uniform cross section subjected to simple bending will be found extremely convenient:

$$\text{Deflection in inches} = \frac{fL^2}{100{,}000{,}000\,c},$$

where f = maximum bending stress on extreme fiber at or near mid-span in lb./sq. in.
L = span length in inches
c = distance from neutral axis to extreme fiber in inches

A study of this deflection formula will show that for a given span length there are two ways the deflection can be reduced: one is to decrease the working stress, and the other is to increase the depth of the beam. The second method is preferable because it is most economical of material. It is well to remember this fact in proportioning members where stiffness is of primary importance.

Latticed Members and Trusses

In calculating deflections of beams by means of the foregoing formula, or by more precise deflection formulas, (Table 21, pages 78 to 81), it is common practice to neglect shearing deformations. This is justified in the case of solid-web beams and girders having span lengths which are fairly long in proportion to the depth of the beam, but it is not justified in the case of members with trussed or latticed webs. If an attempt is made to calculate deflections of open web members by means of the foregoing formula, or by substituting

the moment of inertia of the member in one of the ordinary deflection formulas, the resulting calculated deflection will be considerably less than the actual deflection, the difference being the result of deformations of the web system. The deflections of members with trussed or latticed webs should always be calculated by some method applicable to truss construction, or at least some allowance for deformations of the web should be made.

The foregoing discussion of deflections of open web members applies also to the calculation of stresses in such members. Members with latticed or trussed webs should be designed as trusses and not as beams, and the analysis should include the calculation of stresses in the web members and their connections.

Rivet Spacing in Built-up Members

Many of the members in a structure, particularly the larger members, are built up of plates and shapes riveted together as a unit. In such members the rivets connecting the component parts must be of the proper size and spaced so that the completed member will function as a unit. This is accomplished by spacing the rivets close enough so that: first, a suitable margin of safety is provided against column failure of the parts between rivets, and second, the longitudinal shear on any section can be transferred without exceeding the allowable working stresses in shear and bearing.

The spacing of rivets to prevent column failure of parts between adjacent rivets is simply a matter of adjusting the spacing so that the column strength of the parts is adequate. In order to determine the column strength of the part, the effective slenderness ratio of the part between rivets is substituted in the column formulas (Table 10, page 37), in the usual manner. This should be done not only for the component parts of columns and other compression members, but also for the compression flanges of beams, particularly the compression cover plates.*

The spacing of rivets to resist longitudinal shear is influenced principally by the magnitude of the longitudinal shear. The longitudinal shear varies along the length of a member in proportion to the total shear on the transverse cross section. It also varies with the location of the longitudinal section, being a maximum at the neutral axis and zero at the extreme fiber. The formula for calculating the longitudinal shear is as follows:

*The radius of gyration of a flat plate is equal to 29% of its thickness, regardless of its width.

$$V_L = \frac{VQ}{I},$$

where V_L = shear on any longitudinal section between neutral axis and extreme fiber in lb./lin. in.
V = total shear on transverse section of member at point being investigated in lb.
Q = statical moment of gross area ($\int y\,dA$) of transverse cross section between longitudinal section and extreme fiber with reference to neutral axis of member in in.^{3}
I = moment of inertia of entire transverse section, gross area, in in.^{4}

When using this formula to calculate the shear on a line or lines of rivets, the longitudinal section may be irregular in shape so as to cut only the rivets in question.

The spacing of rivets to resist the longitudinal shear may be found from the following formula:

$$\text{Spacing in inches} = \frac{R}{V_L},$$

where R = value of one rivet in shear or bearing, whichever is smaller, expressed in lb.

Example 13. Determine the spacing of ⅝″ hot-driven 17S rivets connecting the compression flange angles to the web in the girder used in Example 5, page 52, allowable bearing stress to be 25,000 lb./sq. in.

Maximum shear (in end panel), $V = 12{,}460$ lb.

Statical moment of compression flange angles about neutral axis, $Q = (11.4 - 0.77)\ 4.98 = 52.9$ in.^{3}

Calculated longitudinal shear between flange angles and web,

$$V_L = \frac{VQ}{I} = \frac{12{,}460 \times 52.9}{1430} = 460 \text{ lb./lin. in.}$$

Value of one rivet (Table 29, page 154), $R = 0.164 \times 25{,}000 = 4100$ lb. (obviously, bearing controls the design of this double-shear rivet.)

$$\text{Maximum allowable spacing of rivets} = \frac{R}{V_L} = \frac{4100}{460} = 8.9''.$$

This spacing may be considered the maximum allowable in the end panel, based on longitudinal shear alone.

The foregoing formula for the spacing of rivets to resist longitudinal shear applies to columns and other compression members as well as to beams. When a built-up member is subjected to a column load approaching its ultimate strength, the member bends sidewise and the axis of the member becomes tilted with respect to the line of action of the load. The member is therefore subjected to a transverse shear in the plane of bending equal to the load times the sine of the angle between the deflected axis of the member and the line of action of the load. Since the maximum angle occurs at

the ends of the effective length, KL, the maximum shear also occurs at this point. For design purposes the maximum shear may be determined according to the following formula:

$$V = P\frac{\left(f_b - \frac{P}{A}\right)}{f_c} \times \frac{\pi r^2}{KLc},$$

where V = maximum transverse shear on a transverse section of column at ends of effective length, KL, in direction of assumed bending in lb.
P = column load in lb.
A = cross-sectional area of column in sq. in.
f_b = allowable extreme fiber stress (compression) on member considered as a beam in lb./sq. in.
f_c = allowable average stress on member considered as an axially loaded column in lb./sq. in.
r = radius of gyration, same as that used in determining f_c in inches
KL = effective length of member, same as used in determining f_b and f_c in inches
c = distance from centroidal axis to extreme fiber corresponding to f_b in inches.

It is important in the foregoing formula that the values of f_b, f_c, KL, r, and c be selected so that they are consistent with each other and consistent with the direction of bending assumed. Sometimes it may be desirable to investigate bending about two or more axes, or bending in opposite directions about the same axis. More often, however, the transverse shear will be needed in a given direction so that the direction of bending can be selected accordingly.

It should be noted that the value of V given by the above formula is defined as that on a transverse section at the ends of the effective length, KL. This is the maximum value existing throughout the length of the column, the value at the center of the effective length, KL, being zero. Between the center and the end, the value of V on any transverse section may be obtained approximately by direct interpolation. In cantilever compression members loaded so that the line of action of the load is always parallel to its original position ($K = 2.0$), the free end corresponds to the point of maximum shear, V, and the built-in end corresponds to the center of effective length at which the value of V is zero.

The value of V for columns as defined in the foregoing formula is that produced by the column load only. To this should be added the shear produced by any transverse load which may exist. This combination may be substituted directly in the foregoing formula for longitudinal shear, V_L, which in turn may be used to determine the spacing of rivets. The combined transverse shear may also be

used in designing latticing for compression members. Knowing the maximum transverse shear and the approximate distribution of such shear along the length of the member, the latticing can be designed accordingly to resist the tension and compression forces acting on the individual bars. If batten plates are to be used instead of latticing, they should be close enough together so that the bending stresses, introduced into the longitudinal members by the transverse shear acting between batten plates, are not excessive.

Example 14. Determine spacing of ⅝″ hot-driven 17S rivets required to make the two angles function as a unit in the chord member used in Example 1, allowable shear stress to be 11,000 lb./sq. in.

Check for column failure of individual angles.

Calculated column stress, $\frac{P}{A} = 9040$ lb./sq. in.

Corresponding $\frac{KL}{r}$ from column formula (factor of safety of 2.5)

$$= \frac{43{,}800 - 9040 \times 2.5}{350} = 60.6$$

Least radius of gyration of individual angle = 0.64″.

Maximum value of KL for individual angle = 60.6 × 0.64 = 38.8″.

Maximum value of L for individual angle, between rivets, assuming K value of seven tenths, = 38.8/0.7 = 55.4″.

Check for longitudinal shear.

In order to produce longitudinal shear on the rivets connecting the two angles, the member must bend in the horizontal plane about axis Y-Y. For bending in this plane, the following values are found:

$$\frac{KL}{r} = \frac{0.8 \times 120}{1.91} = \frac{96}{1.91} = 50$$

$f_c = (43{,}800 - 350 \times 50) \div 2.5 = 10{,}520$ lb./sq. in.

$f_b = 30{,}000 \div 2 = 15{,}000$ lb./sq. in. (factor of safety of 2 against guaranteed minimum yield strength).

$Q = 2.49 \times 1.45 = 3.61$ in.^{3} (statical moment of one angle about axis Y-Y)

$I = Ar^2 = 4.98 \times \overline{1.91}^2 = 18.2$ in.^{4}

Maximum transverse shear,

$$V = P\,\frac{\left(f_b - \frac{P}{A}\right)}{f_c}\,\frac{\pi r^2}{KL_c} = 45{,}000\,\frac{(15{,}000 - 9040)}{10{,}520}\,\frac{\pi \times \overline{1.91}^2}{96 \times 4.19} = 726 \text{ lb.}$$

Maximum longitudinal shear,

$$V_L = \frac{VQ}{I} = \frac{728 \times 3.61}{18.2} = 144 \text{ lb./lin. in.}$$

Allowable shear value of one rivet (Table 29, page 154),
R = 0.338 × 11,000 = 3720 lb.

Spacing of rivets to resist longitudinal shear $= \frac{3720}{144} = 25.8''$.

This is the controlling spacing for the rivets joining the two angles, because it is less than the 55.4″ required to prevent column failure of the individual angles between rivets.

Web Stiffeners at Concentrated Loads

In the foregoing chapter, formulas are given for determining the critical shear stress on the webs of beams and girders, and it is pointed out that shear buckling is a determining factor in the spacing of web stiffeners. Critical shear, however, is only one of the considerations controlling the spacing of web stiffeners, such stiffeners also being necessary at certain points of concentrated load or reaction. In order to check whether or not a stiffener is needed at points of concentrated load or reaction, it is necessary to calculate the average stress in the web both adjacent to the loaded flange and at the center of the clear height. The following two formulas may be used:

$$\text{Calculated stress in web adjacent to loaded flange} = \frac{P}{tb}\cdot$$

$$\text{Calculated stress in web at center of clear height} = \frac{P}{t(b+ah)}\cdot$$

Where P = concentrated load or reaction in lb.
t = web thickness in inches
b = length along flange over which P is assumed to be distributed in inches
h = clear height of web in inches
a = 1.0 for intermediate loads or reactions
a = 0.5 for loads or reactions at or near end of member

The stress calculated by the first of the above two formulas should not exceed the basic allowable compressive stress on the web, and the stress calculated by the second of the above two formulas should not exceed the allowable stress on the web considered as a column over a length equal to the clear height.* In case either of these allowable stresses is exceeded, it is necessary to strengthen the web by applying stiffeners having a close bearing against the flanges. Such stiffeners must, of course, make up any deficiency in area adjacent to the loaded flange as well as provide sufficient column strength to resist the concentration.

In the case of built-up plate girders, the investigation of stresses in the web adjacent to the loaded flange should also include a check on the rivets to make sure that the latter are capable of transferring safely the concentration from the flange to the web without exceeding the allowable stresses in shear and bearing. When a concentrated load or reaction occurs at a section in which there is considerable longitudinal shear, the stress in the rivets should be calculated for a combination of the two conditions. Since the forces from

*The radius of gyration of a flat plate is equal to 29% of its thickness, regardless of the width.

these two conditions are usually not acting parallel to each other, they are not directly additive, the maximum force being obtained from the well-known parallelogram law.

Sometimes it may be necessary to investigate the need for additional stiffeners to resist concentrated loads which occur between stiffeners spaced according to some other consideration. This is particularly true in the case of a concentrated load moving along the flange. Under such circumstances, the stress adjacent to the loaded flange is checked in exactly the same manner as outlined above, but in checking the stresses at the center of the clear height, advantage may be taken of the stiffening effect of adjacent stiffeners already in place. This is done in determining the allowable column stress in the web. Instead of using the clear height of the web as the length of the column, a reduced length is used as follows:

$$\text{Effective clear height of web} = \frac{h}{\sqrt{1+2\left(\frac{h}{s}\right)^2}},$$

where s = twice the distance from concentrated load to nearest stiffener in inches

h = clear height of web in inches

Connections and Splices

The design of connections and splices in structural members is equally as important as the design of the members themselves. It is highly desirable, of course, that the rivets in connections and splices be arranged so that any axial loads on the members are transmitted without introducing eccentricities. Where it is impossible to avoid such eccentricities, an estimate of their magnitude should be made and their effect should be taken into account in the calculation of stresses in the members. In designing joints which are required to transmit both moment and shear, the stresses in the rivets should be calculated, taking into account both factors. This condition is particularly important in end connections of small beams in which only a few rivets are used to connect the clip angles to the web. In such cases it will often be found that the bending moment on this group of rivets is more severe than the shear.

Care should be taken in designing riveted joints to have the rivets stressed principally in shear and bearing rather than in tension. This is particularly true in joints in which the forces are repeated, because rivets are not well adapted for transmitting repeated ten-

sile loadings. Where such tensile loadings cannot be eliminated, bolts should be substituted for rivets.

Vibration

It is sometimes necessary in structural design to consider the harmful effects of vibration of certain members or of the structure as a whole. In such cases it is necessary to make sure that the natural frequency of vibration of a structure as a whole, or any part of the structure, does not synchronize with the frequency of some impulse which may be repeated for a considerable number of times. It is desirable that the natural frequencies of the structure and its parts lie outside of a range from one-half to twice the frequency of these impulses. The natural frequency of a structure or member may be found approximately by means of the following formula:

Natural frequency of vibration, cycles per second,

$$= \frac{3.13}{\sqrt{D}},$$

where D = deflection at the center of the span of the structure or member resulting from its own weight plus any other weights attached to the member.

In the case of horizontal members, the deflection D is calculated in the ordinary manner, but in the case of members whose position is other than horizontal, the deflection is calculated as though the member were in a horizontal position. This use of the deflection is simply a convenient method of taking into account the modulus of elasticity of the material, the span length of the member, and the magnitude and distribution of the mass which is in motion when the member is vibrating.

Example 15. Find the natural frequency of vibration of the girder used in Example 5, page 52, assuming the loads shown are attached to and vibrate with the girder.

Calculated deflection at center of span, D = 1.06″

$$\text{Natural frequency of vibration} = \frac{3.13}{\sqrt{1.06}} = 3.04 \text{ cycles per second.}$$

Any impulses to which this girder may be subjected should not be repeated steadily in the range from 1.5 to 6 cycles per second. If the frequency of the impulses should lie within this range, stresses might be built up in the member exceeding any ordinary impact allowance which might be made to take care of such dynamic effects.

Example 15a. Check the natural frequency of vibration of the above girder assuming no weights attached to it.

Calculated deflection at center of span, D = 0.016″

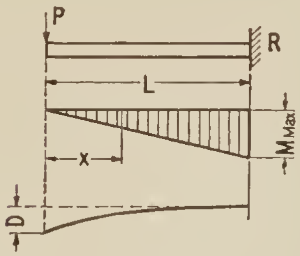
$$\text{Natural frequency of vibration} = \frac{3.13}{\sqrt{0.016}} = 24.8 \text{ cycles per second.}$$

BEAM FORMULAS

TABLE 21—BENDING MOMENTS AND DEFLECTIONS OF BEAMS

1. CANTILEVER BEAM

Concentrated Load at Free End



Reaction = P

Moment at any point = Px

Maximum moment = PL

Maximum deflection $= \frac{PL^3}{3EI}$

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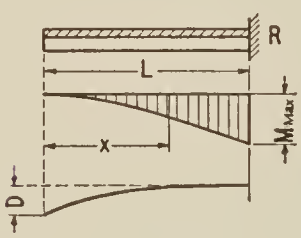
2. CANTILEVER BEAM

Uniform Load, w *per unit of length, total load* W



Reaction = wL = W

Moment at any point $= \frac{wx^2}{2} = \frac{Wx^2}{2L}$

Maximum moment $= \frac{wL^2}{2} = \frac{WL}{2}$

Maximum deflection $= \frac{wL^4}{8EI} = \frac{WL^3}{8EI}$

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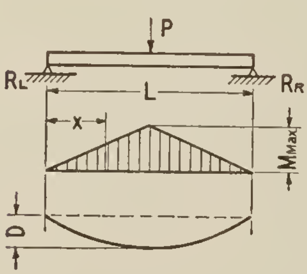
3. SIMPLE BEAM

Concentrated Load at Center



Reactions: $R_L = R_R = \frac{P}{2}$

Moment at any point:

$$x < \frac{L}{2},\ M = \frac{Px}{2}$$

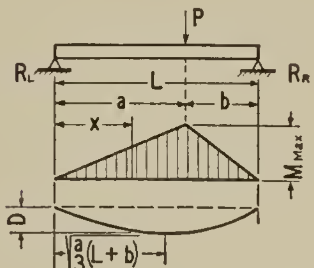
$$x > \frac{L}{2},\ M = \frac{P(L-x)}{2}$$

Maximum moment, at center $= \frac{PL}{4}$

Maximum deflection $= \frac{PL^3}{48EI}$

TABLE 21—BENDING MOMENTS AND DEFLECTIONS OF BEAMS—Continued

4. SIMPLE BEAM
Concentrated Load at any point



Reactions: $R_L = \dfrac{Pb}{L}$, $R_R = \dfrac{Pa}{L}$

Moment at any point:

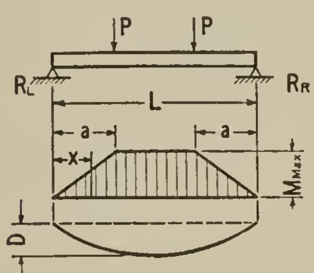
$$x < a,\ M = R_L x = \frac{Pbx}{L}$$

$$x > a,\ M = R_R(L-x) = \frac{Pa(L-x)}{L}$$

Maximum moment, where $x = a$, $M = \dfrac{Pab}{L}$

Maximum deflection, $D = \dfrac{Pab(L+b)\sqrt{3a(L+b)}}{27\ EIL}$

5. SIMPLE BEAM
Two equal concentrated loads, symmetrically placed



Reactions: $R_L = R_R = P$

Moment at any point:

$$x < a,\ M = R_L x = Px$$

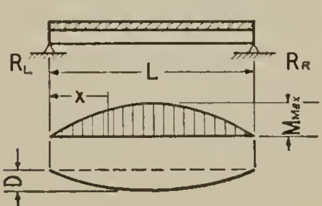
$$a < x < (L-a),\ M = Pa$$

$$x > (L-a),\ M = P(L-x)$$

Maximum moment: $M = Pa$

Maximum deflection $= \dfrac{Pa}{24\ EI}(3L^2 - 4a^2)$

6. SIMPLE BEAM
Uniform Load, w per unit of length, total load W



Reactions: $R_L = R_R = \dfrac{wL}{2} = \dfrac{W}{2}$

Moment at any point:

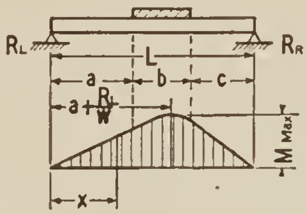
$$M = \frac{wx(L-x)}{2} = \frac{Wx(L-x)}{2L}$$

Maximum moment, at center: $M = \dfrac{wL^2}{8} = \dfrac{WL}{8}$

Maximum deflection: $D = \dfrac{5wL^4}{384\ EI} = \dfrac{5WL^3}{384\ EI}$

TABLE 21—BENDING MOMENTS AND DEFLECTIONS OF BEAMS—Continued

7. SIMPLE BEAM
Uniform Load, w per unit of length, on part of span



Reactions: $R_L = \dfrac{bw(2c+b)}{2L}$, $R_R = \dfrac{bw(2a+b)}{2L}$

Moment at any point:

$$x < a,\ M = R_L x = \frac{bwx(2c+b)}{2L}$$

$$a < x < (a+b),\ M = R_L x - \frac{(x-a)^2 w}{2}$$

$$x > (a+b),\ M = R_R(L-x)$$

$$\text{Maximum moment} = \frac{bw(2c+b)\ [4aL+b(2c+b)]}{8L^2}$$

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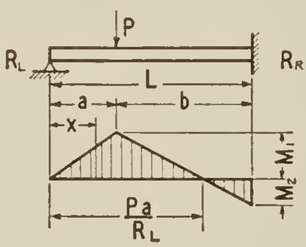
8. BEAM FIXED AT ONE END, SIMPLE SUPPORT AT OTHER
Concentrated Load at any point



Reactions: $R_L = \dfrac{Pb^2}{2L^3}(2L+a)$, $R_R = P - R_L$

Moment at any point:

$$x < a,\ M = R_L x = \frac{Pb^2 x}{2L^3}(2L+a)$$

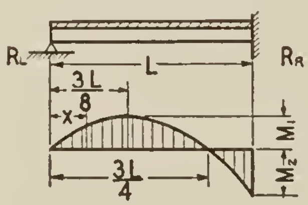
$$x > a,\ M = R_L x - P(x-a)$$

$$x = L,\ M_2 = \frac{-Pab}{2L^2}(L+a)$$

$$M_1 = \frac{Pab^2}{2L^3}(2L+a)$$

---

9. BEAM FIXED AT ONE END, SIMPLE SUPPORT AT OTHER
Uniform Load, w per unit of length



Reactions: $R_L = \dfrac{3}{8}wL$, $R_R = \dfrac{5}{8}wL$

Moment at any point:

$$x < L,\ M = wx\left(\frac{3L}{8} - \frac{x}{2}\right)$$

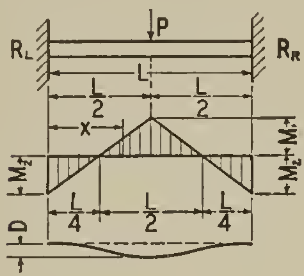
$$x = L,\ M_2 = \frac{-wL^2}{8}$$

$$M_1 = \frac{9wL^2}{128}$$

TABLE 21—BENDING MOMENTS AND DEFLECTIONS OF BEAMS—Concluded

10. BEAM FIXED AT BOTH ENDS

Concentrated Load at center



Reactions: $R_L = R_R = \dfrac{P}{2}$

Moment at any point:

$$x = 0,\ x = L,\ M_2 = \frac{-PL}{8}$$

$$x < \frac{L}{2},\ M = \frac{-P}{2}\left(\frac{L}{4} - x\right)$$

$$x > \frac{L}{2},\ M = \frac{P}{2}\left(\frac{3L}{4} - x\right)$$

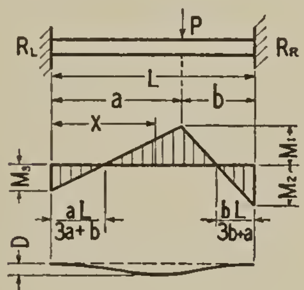
$$M_1 = \frac{PL}{8}$$

Maximum deflection $= \dfrac{PL^3}{192\ EI}$

---

11. BEAM FIXED AT BOTH ENDS

Concentrated Load at any point



Reactions: $R_L = \dfrac{Pb^2}{L^3}(L+2a)$, $R_R = \dfrac{Pa^2}{L^3}(L+2b)$

Moment at any point:

$$x = 0,\ M_3 = \frac{-Pab^2}{L^2}$$

$$x < a,\ M = \frac{-Pab^2}{L^2} + R_L x$$

$$x > a,\ M = \frac{-Pa^2b}{L^2} + R_R(L-x)$$

$$x = L,\ M_2 = \frac{-Pa^2b}{L^2}$$

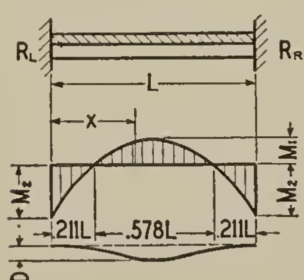
$$M_1 = \frac{2Pa^2b^2}{L^3}$$

Maximum deflection, $a > b$, $= \dfrac{2\ P\ a^3b^2}{3\ E\ I\ (3a+b)^2}$

---

12. BEAM FIXED AT BOTH ENDS

Uniform Load, w per unit of length, total load W



Reactions: $R_L = R_R = \dfrac{wL}{2} = \dfrac{W}{2}$

Moment at any point:

$$x = 0,\ x = L,\ M_2 = \frac{-wL^2}{12} = \frac{-WL}{12}$$

$$x < L,\ M = \frac{-wL^2}{12} - \frac{wx^2}{2} + \frac{wLx}{2}$$

$$M_1 = \frac{wL^2}{24} = \frac{WL}{24}$$

Maximum deflection $= \dfrac{wL^4}{384\ EI}$

ELEMENTS OF SECTIONS

STRUCTURAL SHAPES, RECTANGLES, TUBES, AND FORMULAS

STRUCTURAL SHAPES

Elements of Sections

THE DATA given on the following pages include the section elements commonly used in design. All values have been computed on the basis of the nominal dimensions shown; the actual dimensions of a member will usually overrun slightly, depending on the condition of the rolls or die. Fillets and roundings have been included throughout all calculations except those for the torsion factor, J.

On the profiles shown, axes X-X and Y-Y are the axes of maximum and minimum moments of inertia, respectively, for sections having an axis of symmetry. Axis Z-Z is the axis of least moment of inertia for unsymmetrical sections. Each is the neutral axis for flexure in the plane at right angles to the axis.

The moment of inertia, I, is a convenient value representing the expression, $\int y^2dA$, which appears in the derivation of the well-known flexure formula. The moment of inertia of any structural shape about a given axis, however, is obtained not by actual integration over the entire area, but by breaking the area up into a few convenient parts, calculating the individual moments of inertia of these parts about the axis in question by means of the theorem of parallel axes, and summing up these individual values. The term, I, appears in the formulas for deflections of beams in Table 21.

The section modulus, S, about a given axis, may be defined as the quotient obtained by dividing the moment of inertia by the distance of the extreme fiber of the section from the axis considered $\left(S=\frac{I}{c}\right)$. This term is used in calculating extreme fiber stress in beams, the stress being the bending moment divided by the section modulus.

The radius of gyration, r, about a given axis, may be defined as the square root of the quotient obtained by dividing the moment of inertia by the area of the section $\left(r=\sqrt{\frac{I}{A}}\right)$. This term is used in the determination of column strength, the length of a member divided by its radius of gyration being the slenderness ratio.

The torsion factor, J, is a measure of the resistance of a section to twisting in simple torsion in much the same way that I is a measure of resistance to deflection in simple bending. For structural shapes this term is not the polar moment of inertia as it would be

for round rods or tubes, but it may be used in exactly the same manner to determine angle of twist for a given torque according to the formula:

$$\Theta = \frac{T}{JG},$$

where Θ = angle of twist, radians per inch of length
T = torque in inch-pound
J = torsion factor in in.^{4}
G = modulus of rigidity (3,800,000 lb./sq. in. for aluminum alloys)

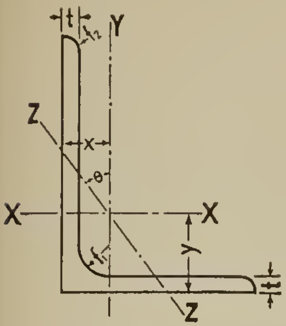
The term J enters into the determination of the lateral stability of beams (page 48).

The weights given are for 17S and 27S[1] alloys. The weights based on other alloys may be found as follows:

For 3S multiply by 0.978
For 53S multiply by 0.964

The range of sizes which Aluminum Company of America mills are capable of producing are indicated in the tables, but tools are not available for all sizes of shapes shown. Under the heading "Tools," shapes which are usually produced by rolling are shown by the notation "Rolls." In the case of shapes produced exclusively by extrusion, the die number is given. Tools for the production of other shapes will be added as the demand warrants.

[1]Special purpose alloy. See page 19.



ANGLES

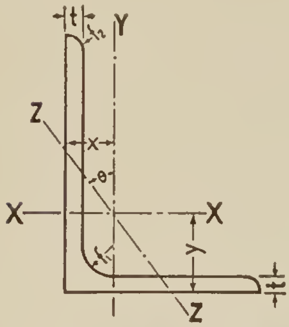
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.⁴

S = Section Modulus in in.³
r = Radius of Gyration in inches.
J = Torsion Factor in in.⁴

Size	Legs	½ x ½	⅝ x ⅝		¾ x ⅜	¾ x ¾			
	t	1/16	3/32	1/8	3/32	1/16	3/32	1/8	3/16
	Weight	0.071	0.134	0.169	0.120	0.108	0.159	0.207	0.297
	Area	0.059	0.111	0.140	0.099	0.089	0.132	0.171	0.246
	f_1	1/16	1/8	1/16	1/8	1/8	1/8	1/8	1/8
	f_2	1/32	3/64	1/16	3/64	3/32	3/32	3/32	3/32
Axis X-X	I	0.0013	0.0037	0.0046	0.0054	0.0043	0.0063	0.0082	0.0112
	S	0.0038	0.0084	0.0109	0.0114	0.0079	0.0118	0.0157	0.0224
	r	0.150	0.183	0.182	0.232	0.220	0.219	0.219	0.214
	y	0.146	0.187	0.199	0.279	0.199	0.214	0.227	0.251
Axis Y-Y	I	0.0013	0.0037	0.0046	0.0009	0.0043	0.0063	0 0082	0.0112
	S	0.0038	0.0084	0.0109	0.0031	0.0079	0.0118	0.0157	0.0224
	r	0.150	0.183	0.182	0.094	0.220	0.219	0.219	0.214
	x	0.146	0.187	0.199	0.098	0.199	0.214	0.227	0.251
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	13° 44′	45° 0′	45° 0′	45° 0′	45° 0′
	I	0.0006	0.0015	0.0020	0.0006	0.0018	0.0026	0.0034	0.0049
	r	0.097	0.117	0.120	0.077	0.142	0.141	0.141	0.141
	J	0.00008	0.00034	0.00081	0.00031	0.00012	0.00041	0.00098	0.0033
	Tools	78-P	77-G	485	734-A	78-K	Rolls	Rolls	Rolls

Size	Legs	1 x ⅝		1 x ¾	1 x 1				
	t	1/8	1/4	1/8	1/16	3/32	1/8	3/16	1/4
	Weight	0.226	0.418	0.245	0.147	0.216	0.283	0,411	0.529
	Area	0.187	0.345	0.202	0.122	0.178	0.234	0.339	0.437
	f_1	1/16	1/8	1/16	1/16	1/8	1/8	1/8	1/8
	f_2	1/16	1/16	1/16	1/32	3/32	3/32	3/32	3/32
Axis X-X	I	0.0181	0.0306	0.0194	0.0118	0.0161	0.0208	0.0291	0.0361
	S	0.0279	0.0507	0.0288	0.0162	0.0223	0.0293	0.0424	0.0544
	r	0.312	0.298	0.309	0.311	0.301	0.298	0.293	0.287
	y	0.351	0.396	0.329	0.271	0.276	0.290	0.314	0.336
Axis Y-Y	I	0.0054	0.0089	0.0092	0.0118	0.0161	0.0208	0.0291	0.0361
	S	0.0117	0.0215	0.0169	0.0162	0.0223	0.0293	0.0424	0.0544
	r	0.170	0.161	0.214	0.311	0.301	0.298	0.293	0.287
	x	0.165	0.210	0.205	0.271	0.276	0.290	0.314	0.336
Axis Z-Z	Θ	20° 34′	9° 08′	28° 23′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	0.0033	0.0084	0.0051	0.0048	0.0066	0.0085	0.0124	0.0162
	r	0.132	0.156	0.158	0.199	0.193	0.191	0.191	0.193
	J	0.00106	0.00846	0.00114	0.00016	0.00055	0.00130	0 00439	0.01042
	Tools	734-5	734-4	734-JJ	78-J	Rolls	Rolls	Rolls	Rolls



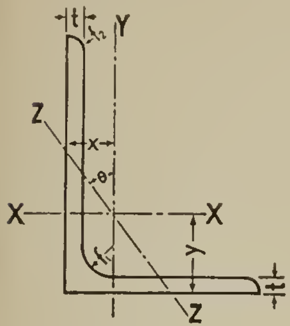
ANGLES

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}

Size	Legs	1⅛ x 1⅛	1¼ x ¾	1¼ x 1	1¼ x 1¼				
	t	⅛	3/32	⅛	3/32	⅛	3/16	¼	5/16
	Weight	0.32	0.22	0.32	0.28	0.36	0.53	0.68	0.83
	Area	0.27	0.18	0.27	0.23	0.30	0.43	0.56	0.68
	f_1	3/16	3/32	⅛	3/32	3/16	3/16	3/16	3/16
	f_2	⅛	3/64	1/16	3/64	⅛	⅛	⅛	⅛
Axis X-X	I	0.030	0.029	0.040	0.033	0.042	0.059	0.074	0.088
	S	0.037	0.035	0.047	0.036	0.046	0.068	0.087	0.106
	r	0.33	0.40	0.39	0.38	0.37	0.37	0.36	0.36
	y	0.32	0.42	0.39	0.34	0.35	0.37	0.40	0.42
Axis Y-Y	I	0.030	0.008	0.023	0.033	0.042	0.059	0.074	0.088
	S	0.037	0.014	0.031	0.036	0.046	0.068	0.087	0.106
	r	0.33	0.21	0.29	0.38	0.37	0.37	0.36	0.36
	x	0.32	0.17	0.27	0.34	0.35	0.37	0.40	0.42
Axis Z-Z	Θ	45° 0′	19° 47′	31° 51′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	0.012	0.005	0.012	0.014	0.017	0.025	0.032	0.040
	r	0.21	0.16	0.21	0.24	0.24	0.24	0.24	0.24
	J	0.0015	0.0005	0.0015	0.0007	0.0016	0.0055	0.013	0.025
	Tools	78-U	734-FF	734-HH	Rolls	Rolls	Rolls	Rolls	Rolls

Size	Legs	1½ x ¾		1½ x ⅞	1½ x 1		1½ x 1¼		
	t	⅛	3/16	3/16	5/32	¼	⅛	3/16	¼
	Weight	0.32	0.47	0.50	0.45	0.68	0.40	0.58	0.76
	Area	0.27	0.39	0.41	0.37	0.56	0.33	0.48	0.63
	f_1	⅛	⅛	⅛	5/32	3/16	3/16	3/16	3/16
	f_2	1/16	3/32	3/32	5/64	⅛	⅛	⅛	⅛
Axis X-X	I	0.061	0.085	0.090	0.080	0.117	0.070	0.100	0.127
	S	0.064	0.091	0.093	0.081	0.122	0.066	0.097	0.126
	r	0.48	0.47	0.47	0.47	0.46	0.46	0.46	0.45
	y	0.54	0.57	0.54	0.50	0.53	0.44	0.47	0.49
Axis Y-Y	I	0.010	0.014	0.022	0.027	0.040	0.044	0.063	0.079
	S	0.018	0.025	0.034	0.036	0.057	0.047	0.069	0.090
	r	0.20	0.19	0.23	0.27	0.27	0.37	0.36	0.36
	x	0.17	0.19	0.23	0.26	0.29	0.32	0.35	0.37
Axis Z-Z	Θ	14° 25′	13° 45′	18° 08′	23° 02′	22° 23′	33° 59′	33° 53′	33° 36′
	I	0.007	0.009	0.014	0.015	0.025	0.022	0.032	0.041
	r	0.16	0.16	0.18	0.20	0.21	0.26	0.26	0.26
	J	0.0015	0.0049	0.0052	0.0032	0.0130	0.0018	0.0060	0.0143
	Tools	734-EE	734-11	734-7	734-GG	734-WW	734-CC	734-LL	734-SS



ANGLES

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
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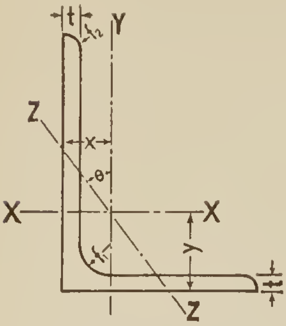
J = Torsion Factor in in.^{4}

Size	Legs	1 1/2 x 1 1/2						1 5/8 x 1 1/4	1 3/4 x 1 1/8
	t	3/32	1/8	3/16	1/4	5/16	3/8	1/8	3/16
	Weight	0.33	0.44	0.64	0.83	1.02	1.19	0.41	0.61
	Area	0.28	0.36	0.53	0.69	0.84	0.99	0.34	0.51
	f_1	3/16	3/16	3/16	3/16	3/16	3/16	1/8	3/16
	f_2	1/8	1/8	1/8	1/8	1/8	1/8	1/8	3/32
Axis X-X	I	0.058	0.074	0.107	0.135	0.161	0.184	0.087	0.152
	S	0.053	0.068	0.100	0.130	0.158	0.185	0.077	0.132
	r	0.46	0.45	0.45	0.44	0.44	0.43	0.51	0.55
	y	0.40	0.41	0.44	0.46	0.48	0.51	0.50	0.59
Axis Y-Y	I	0.058	0.074	0.107	0.135	0.161	0.184	0.045	0.049
	S	0.053	0.068	0.100	0.130	0.158	0.185	0.048	0.058
	r	0.46	0.45	0.45	0.44	0.44	0.43	0.36	0.31
	x	0.40	0.41	0.44	0.46	0.48	0.51	0.31	0.29
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	29° 55′	21° 47′
	I	0.024	0.031	0.044	0.057	0.070	0.083	0.024	0.029
	r	0.30	0.29	0.29	0.29	0.29	0.29	0.26	0.24
	J	0.0008	0.0020	0.0066	0.016	0.031	0.053	0.0019	0.0063
	Tools	Rolls	Rolls	Rolls	Rolls	Rolls	78-DD	734-2	734-E

Size	Legs	1 3/4 x 1 1/4			1 3/4 x 1 3/4					
	t	1/8	3/16	1/4	3/32	1/8	3/16	1/4	5/16	3/8
	Weight	0.44	0.64	0.83	0.39	0.51	0.75	0.98	1.21	1.42
	Area	0.36	0.53	0.69	0.32	0.42	0.62	0.81	1.00	1.17
	f_1	3/16	3/16	3/16	3/32	3/16	3/16	3/16	3/16	3/16
	f_2	1/8	1/8	1/8	3/64	1/8	1/8	1/8	1/8	1/8
Axis X-X	I	0.108	0.156	0.199	0.096	0.121	0.174	0.223	0.266	0.306
	S	0.090	0.132	0.172	0.075	0.094	0.139	0.181	0.221	0.259
	r	0.55	0.54	0.54	0.55	0.53	0.53	0.52	0.52	0.51
	y	0.54	0.57	0.60	0.47	0.47	0.50	0.52	0.55	0.57
Axis Y-Y	I	0.046	0.066	0.083	0.096	0.121	0.174	0.223	0.266	0.306
	S	0.048	0.071	0.092	0.075	0.094	0.139	0.181	0.221	0.259
	r	0.36	0.35	0.35	0.55	0.53	0.53	0.52	0.52	0.51
	x	0.30	0.32	0.35	0.47	0.47	0.50	0.52	0.55	0.57
Axis Z-Z	Θ	26° 22′	26° 08′	25° 47′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	0.026	0.037	0.048	0.039	0.050	0.072	0.093	0.113	0.134
	r	0.27	0.26	0.26	0.35	0.34	0.34	0.34	0.34	0.34
	J	0.0020	0.0066	0.016	0.0010	0.0023	0.0077	0.018	0.036	0.062
	Tools	734-V	734-O	734-XX	78-L	77-E	77-U	77-W		



ANGLES

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
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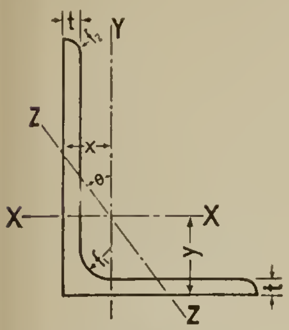
J = Torsion Factor in in.^{4}

Size	Legs	2 x 1¼			2 x 1⅜	2 x 1½				
	t	⅛	3/16	¼	¼	⅛	3/16	¼	5/16	⅜
	Weight	0.47	0.70	0.91	0.95	0.51	0.75	0.98	1.21	1.42
	Area	0.39	0.58	0.75	0.79	0.42	0.62	0.81	1.00	1.17
	f_1	3/16	3/16	3/16	¼	3/16	3/16	3/16	3/16	3/16
	f_2	⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛
Axis X-X	I	0.158	0.228	0.291	0.302	0.17	0.24	0.31	0.37	0.43
	S	0.117	0.172	0.224	0.228	0.12	0.18	0.23	0.28	0.33
	r	0.63	0.63	0.62	0.62	0.63	0.62	0.62	0.61	0.60
	y	0.65	0.68	0.70	0.68	0.60	0.63	0.66	0.68	0.70
Axis Y-Y	I	0.047	0.068	0.086	0.114	0.08	0.12	0.15	0.18	0.20
	S	0.049	0.072	0.093	0.113	0.07	0.10	0.14	0.16	0.19
	r	0.35	0.34	0.34	0.38	0.44	0.43	0.43	0.42	0.41
	x	0.28	0.31	0.33	0.37	0.36	0.38	0.41	0.43	0.45
Axis Z-Z	Θ	21° 05′	20° 52′	20° 31′	24° 14′	28° 44′	28° 36′	28° 20′	28° 0′	27° 37′
	I	0.028	0.041	0.053	0.067	0.04	0.06	0.08	0.10	0.12
	r	0.27	0.27	0.26	0.29	0.32	0.32	0.32	0.32	0.32
	J	0.0021	0.0071	0.017	0.018	0.0023	0.0077	0.018	0.036	0.062
	Tools	734-P	734-N	734-12	734-KK	734-TT	Rolls	Rolls	Rolls	Rolls

Size	Legs	2 x 1¾	2 x 2						2¼ x 1½
	t	¼	⅛	3/16	¼	5/16	⅜	7/16	¼
	Weight	1.07	0.59	0.87	1.14	1.40	1.65	1.89	1.07
	Area	0.88	0.49	0.72	0.94	1.16	1.37	1.57	0.88
	f_1	¼	¼	¼	¼	¼	¼	¼	¼
	f_2	⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛
Axis X-X	I	0.33	0.18	0.27	0.34	0.41	0.47	0.53	0.43
	S	0.24	0.13	0.19	0.24	0.30	0.35	0.39	0.29
	r	0.61	0.61	0.61	0.60	0.60	0.59	0.58	0.70
	y	0.62	0.53	0.56	0.58	0.61	0.63	0.65	0.76
Axis Y-Y	I	0.23	0.18	0.27	0.34	0.41	0.47	0.53	0.15
	S	0.18	0.13	0.19	0.24	0.30	0.35	0.39	0.14
	r	0.51	0.61	0.61	0.60	0.60	0.59	0.58	0.42
	x	0.49	0.53	0.56	0.58	0.61	0.63	0.65	0.39
Axis Z-Z	Θ	34° 44′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	23° 09′
	I	0.11	0.08	0.11	0.14	0.17	0.20	0.23	0.09
	r	0.36	0.40	0.39	0.39	0.39	0.39	0.39	0.32
	J	0.020	0.0026	0.0088	0.021	0.041	0.070	0.112	0.020
	Tools	734-13	77-V	Rolls	Rolls	Rolls	Rolls		734-MM



ANGLES

ELEMENTS OF SECTIONS

All dimensions in inches.
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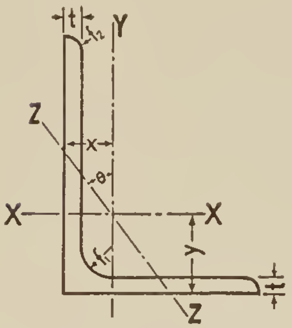
Size	Legs	2½ x 1¼			2½ x 1½				
	t	1/8	3/16	1/4	1/8	3/16	1/4	5/16	3/8
	Weight	0.55	0.82	1.07	0.59	0.87	1.14	1.40	1.65
	Area	0.46	0.68	0.88	0.49	0.72	0.94	1.16	1.37
	f_1	3/16	1/4	1/4	1/4	1/4	1/4	3/16	1/4
	f_2	3/32	3/32	3/32	1/8	1/8	1/8	1/8	1/8
Axis X-X	I	0.30	0.43	0.55	0.31	0.46	0.59	0.71	0.82
	S	0.18	0.27	0.35	0.19	0.27	0.36	0.44	0.51
	r	0.81	0.80	0.79	0.80	0.79	0.79	0.78	0.77
	v	0.87	0.89	0.92	0.80	0.84	0.86	0.89	0.91
Axis Y-Y	I	0.05	0.07	0.09	0.09	0.12	0.16	0.19	0.22
	S	0 05	0.08	0.10	0.07	0.11	0.14	0.17	0.20
	r	0.34	0.33	0.32	0.42	0.41	0.41	0.40	0.40
	x	0.25	0.28	0.30	0.32	0.35	0.37	0.39	0.42
Axis Z-Z	Θ	14° 45′	14° 29′	14° 10′	19° 40′	19° 38′	19° 25′	19° 06′	18° 42′
	I	0.03	0.05	0.06	0.05	0.08	0.10	0.12	0.14
	r	0.27	0.27	0.26	0.33	0.32	0.32	0.32	0.32
	J	0.0024	0.0082	0.020	0.0026	0.0088	0.021	0.041	0.070
	Tools	734-6	734-H			734-T	734-RR	734-8	

Size	Legs	2½ x 2						
	t	1/8	3/16	1/4	5/16	3/8	7/16	1/2
	Weight	0.67	0.99	1.29	1.59	1.88	2.16	2.43
	Area	0.55	0.82	1.07	1.32	1.55	1.78	2.01
	f_1	1/4	1/4	1/4	1/4	1/4	1/4	1/4
	f_2	1/8	1/8	1/8	1/8	1/8	1/8	1/8
Axis X-X	I	0.34	0.50	0.65	0.78	0.91	1.02	1.13
	S	0.19	0.29	0.38	0.46	0.54	0.62	0.69
	r	0.79	0.78	0.78	0.77	0.76	0.76	0.75
	v	0.72	0.75	0.78	0.80	0.83	0.85	0.87
Axis Y-Y	I	0.20	0.29	0.37	0.44	0.51	0.57	0.63
	S	0.13	0.19	0.25	0.30	0.36	0.41	0.46
	r	0.60	0.59	0.58	0.58	0.57	0.57	0.56
	x	0.48	0.51	0.53	0.55	0.58	0.60	0.62
Axis Z-Z	Θ	31° 57′	31° 58′	31° 51′	31° 41′	31° 28′	31° 13′	30° 56′
	I	0.10	0.15	0.19	0.23	0.27	0.31	0.35
	r	0.43	0.42	0.42	0.42	0.42	0.42	0.42
	J	0.0029	0.010	0.023	0.046	0.079	0.126	0.188
	Tools	734-S	Rolls	Rolls	Rolls	Rolls		



ANGLES

ELEMENTS OF SECTIONS

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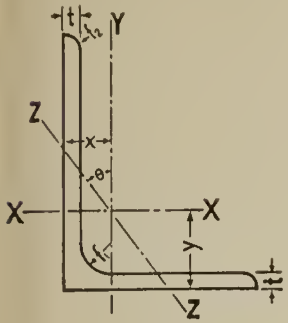
Size		2½ x 2½							3 x 1½
Legs	t	⅛	3/16	¼	5/16	⅜	7/16	½	¼
Weight		0.75	1.10	1.45	1.78	2.11	2.42	2.73	1.30
Area		0.62	0.91	1.19	1.47	1.74	2.00	2.26	1.08
f_1		¼	¼	¼	¼	¼	¼	¼	5/16
f_2		⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛
Axis X-X	I	0.37	0.54	0.69	0.84	0.98	1.10	1.22	0.98
	S	0.20	0.30	0.39	0.48	0.56	0.64	0.72	0.51
	r	0.77	0.77	0.76	0.76	0.75	0.74	0.73	0.95
	y	0.65	0.68	0.71	0.73	0.76	0.78	0.80	1.08
Axis Y-Y	I	0.37	0.54	0.69	0.84	0.98	1.10	1.22	0.16
	S	0.20	0.30	0.39	0.48	0.56	0.64	0.72	0.14
	r	0.77	0.77	0.76	0.76	0.75	0.74	0.73	0.39
	x	0.65	0.68	0.71	0.73	0.76	0.78	0.80	0.34
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	14° 22′
	I	0.15	0.22	0.29	0.35	0.41	0.47	0.53	0.11
	r	0.50	0.49	0.49	0.49	0.48	0.48	0.48	0.32
J		0.0033	0.011	0.026	0.051	0.088	0.140	0.208	0.023
Tools		78-BB	Rolls	Rolls	Rolls	Rolls	77-N		734-L

Size		3 x 2						3 x 2½				
Legs	t	3/16	¼	5/16	⅜	7/16	½	¼	5/16	⅜	7/16	½
Weight		1.10	1.44	1.78	2.11	2.42	2.73	1.58	1.95	2.32	2.67	3.02
Area		0.91	1.19	1.47	1.74	2.00	2.26	1.31	1.62	1.92	2.21	2.49
f_1		5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16
f_2		3/16	3/16	3/16	3/16	3/16	3/16	¼	¼	¼	¼	¼
Axis X-X	I	0.82	1.06	1.29	1.51	1.71	1.90	1.12	1.37	1.60	1.82	2.03
	S	0.40	0.52	0.65	0.76	0.88	0.99	0.53	0.66	0.78	0.90	1.01
	r	0.95	0.94	0.94	0.93	0.92	0.92	0.92	0.92	0.91	0.91	0.90
	y	0.94	0.97	1.00	1.03	1.05	1.07	0.89	0.92	0.94	0.97	0.99
Axis Y-Y	I	0.29	0.38	0.45	0.53	0.59	0.66	0.70	0.86	1.00	1.14	1.26
	S	0.19	0.25	0.30	0.36	0.41	0.46	0.38	0.47	0.55	0.64	0.72
	r	0.56	0.56	0.56	0.55	0.55	0.54	0.73	0.73	0.72	0.72	0.71
	x	0.46	0.48	0.51	0.53	0.56	0.58	0.64	0.67	0.69	0.72	0.74
Axis Z-Z	Θ	23° 25′	23° 22′	23° 13′	23° 0′	22° 44′	22° 25′	34°03′	34° 0′	33°54′	33°46′	33°37′
	I	0.17	0.22	0.27	0.31	0.36	0.40	0.35	0.43	0.51	0.58	0.65
	r	0.43	0.43	0.43	0.42	0.42	0.42	0.52	0.51	0.51	0.51	0.51
J		0.011	0.026	0.051	0.088	0.140	0.208	0.029	0.056	0.097	0.154	0.229
Tools		734-1	734-G	734-10	734-PP	734-QQ		734-J	734-ZZ	734-C		



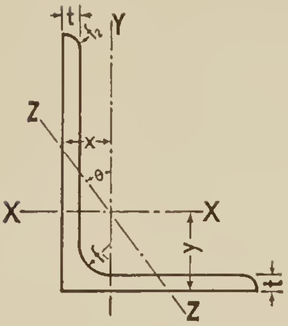
ANGLES

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}

Size	Legs	3 x 3							
	t	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8
	Weight	1.33	1.73	2.14	2.55	2.94	3.32	3.69	4.06
	Area	1.10	1.43	1.77	2.10	2.43	2.74	3.05	3.35
	f_1	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16
	f_2	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4
Axis X-X	I	0.93	1.18	1.45	1.70	1.94	2.16	2.37	2.57
	S	0.42	0.54	0.67	0.80	0.92	1.04	1.15	1.26
	r	0.92	0.91	0.91	0.90	0.89	0.89	0.88	0.88
	y	0.80	0.82	0.85	0.87	0.90	0.92	0.94	0.97
Axis Y-Y	I	0.93	1.18	1.45	1.70	1.94	2.16	2.37	2.57
	S	0.42	0.54	0.67	0.80	0.92	1.04	1.15	1.26
	r	0.92	0.91	0.91	0.90	0.89	0.89	0.88	0.88
	x	0.80	0.82	0.85	0.87	0.90	0.92	0.94	0.97
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	0.38	0.49	0.60	0.70	0.81	0.91	1.01	1.12
	r	0.59	0.58	0.58	0.58	0.58	0.58	0.58	0.58
	J	0.013	0.031	0.061	0.105	0.167	0.250	0.356	0.488
	Tools	Rolls	Rolls	Rolls	Rolls		78-T		

Size	Legs	3½ x 2½					3½ x 3				
	t	1/4	5/16	3/8	7/16	1/2	1/4	5/16	3/8	7/16	1/2
	Weight	1.73	2.14	2.55	2.94	3.32	1.89	2.34	2.78	3.21	3.63
	Area	1.43	1.77	2.10	2.43	2.74	1.57	1.94	2.30	2.66	3.00
	f_1	5/16	5/16	5/16	5/16	5/16	3/8	3/8	3/8	3/8	3/8
	f_2	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4
Axis X-X	I	1.73	2.12	2.49	2.84	3.17	1.84	2.26	2.65	3.03	3.38
	S	0.72	0.89	1.06	1.22	1.37	0.74	0.92	1.09	1.26	1.42
	r	1.10	1.09	1.09	1.08	1.08	1.08	1.08	1.07	1.07	1.06
	y	1.09	1.12	1.14	1.17	1.19	1.01	1.04	1.06	1.09	1.11
Axis Y-Y	I	0.73	0.89	1.05	1.19	1.32	1.28	1.52	1.79	2.04	2.27
	S	0.38	0.48	0.57	0.65	0.73	0.57	0.69	0.82	0.94	1.06
	r	0.71	0.71	0.71	0.70	0.69	0.90	0.89	0.88	0.88	0.87
	x	0.60	0.62	0.65	0.67	0.70	0.76	0.79	0.82	0.84	0.86
Axis Z-Z	Θ	26° 23′	26° 18′	26° 10′	26° 0′	25° 48′	36° 13′	35° 40′	35° 37′	35° 32′	35° 26′
	I	0.41	0.50	0.59	0.67	0.76	0.63	0.74	0.87	1.00	1.13
	r	0.53	0.53	0.53	0.53	0.53	0.63	0.62	0.62	0.61	0.61
	J	0.031	0.061	0.105	0.167	0.250	0.034	0.066	0.114	0.181	0.271
	Tools	734-D	734-UU				734-BB				734-NN



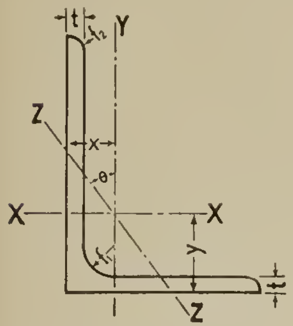
ANGLES

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}

Size	Legs	3½ x 3½						
	t	¼	5/16	⅜	7/16	½	9/16	⅝
	Weight	2.05	2.53	3.01	3.48	3.94	4.39	4.83
	Area	1.69	2.09	2.49	2.87	3.25	3.62	3.99
	f_1	⅜	⅜	⅜	⅜	⅜	⅜	⅜
	f_2	¼	¼	¼	¼	¼	¼	¼
Axis X-X	I	1.93	2.37	2.79	3.18	3.56	3.92	4.26
	S	0.76	0.94	1.11	1.28	1.45	1.61	1.77
	r	1.07	1.06	1.06	1.05	1.05	1.04	1.03
	y	0.94	0.97	1.00	1.02	1.05	1.07	1.09
Axis Y-Y	I	1.93	2.37	2.79	3.18	3.56	3.92	4.26
	S	0.76	0.94	1.11	1.28	1.45	1.61	1.77
	r	1.07	1.06	1.06	1.05	1.05	1.04	1.03
	x	0.94	0.97	1.00	1.02	1.05	1.07	1.09
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	0.80	0.98	1.15	1.32	1.49	1.65	1.81
	r	0.69	0.68	0.68	0.68	0.68	0.67	0.67
	J	0.036	0.071	0.123	0.195	0.292	0.415	0.570
	Tools	78-G	78-CC			77-Z		

Size	Legs	4 x 3							4 x 3½			
	t	¼	5/16	⅜	7/16	½	9/16	⅝	5/16	⅜	7/16	½
	Weight	2.05	2.53	3.01	3.48	3.94	4.39	4.83	2.70	3.22	3.72	4.22
	Area	1.69	2.09	2.49	2.87	3.25	3.62	3.99	2.23	2.66	3.08	3.49
	f_1	⅜	⅜	⅜	⅜	⅜	⅜	⅜	⅜	⅜	⅜	⅜
	f_2	¼	¼	¼	¼	¼	¼	¼	5/16	5/16	5/16	5/16
Axis X-X	I	2.68	3.29	3.88	4.43	4.96	5.47	5.95	3.40	4.02	4.61	5.17
	S	0.96	1.19	1.42	1.63	1.85	2.05	2.25	1.19	1.43	1.65	1.87
	r	1.26	1.25	1.25	1.24	1.24	1.23	1.22	1.23	1.23	1.22	1.22
	y	1.21	1.24	1.26	1.29	1.31	1.34	1.36	1.15	1.18	1.21	1.23
Axis Y-Y	I	1.29	1.58	1.86	2.12	2.36	2.60	2.82	2.42	2.85	3.27	3.67
	S	0.56	0.70	0.83	0.96	1.08	1.20	1.32	0.93	1.11	1.29	1.46
	r	0.87	0.87	0.86	0.86	0.85	0.85	0.84	1.04	1.04	1.03	1.03
	x	0.72	0.74	0.77	0.79	0.82	0.84	0.86	0.91	0.94	0.96	0.99
Axis Z-Z	Θ	28° 42′	28° 40′	28° 35′	28° 28′	28° 20′	28° 11′	28° 0′	36° 54′	36° 53′	36° 50′	36° 46′
	I	0.70	0.85	1.01	1.15	1.30	1.44	1.58	1.15	1.36	1.57	1.77
	r	0.64	0.64	0.64	0.63	0.63	0.63	0.63	0.72	0.72	0.71	0.71
	J	0.036	0.071	0.123	0.195	0.292	0.415	0.570	0.076	0.132	0.209	0.313
	Tools	Rolls	Rolls	Rolls	Rolls	Rolls	Rolls	Rolls		734-AA		



ANGLES

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
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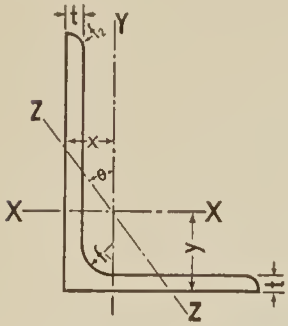
J = Torsion Factor in in.^{4}

Size	Legs	4 x 4								
	t	¼	5/16	⅜	7/16	½	9/16	⅝	11/16	¾
	Weight	2.35	2.91	3.46	4.01	4.54	5.07	5.58	6.09	6.58
	Area	1.94	2.41	2.86	3.31	3.75	4.19	4.61	5.03	5.44
	f_1	⅜	⅜	⅜	⅜	⅜	⅜	⅜	⅜	⅜
	f_2	¼	¼	¼	¼	¼	¼	¼	¼	¼
Axis X-X	I	2.94	3.61	4.26	4.87	5.46	6.02	6.56	7.08	7.57
	S	1.00	1.24	1.48	1.71	1.93	2.15	2.36	2.57	2.77
	r	1.23	1.23	1.22	1.21	1.21	1.20	1.19	1.19	1.18
	y	1.07	1.10	1.12	1.15	1.17	1.20	1.22	1.24	1.26
Axis Y-Y	I	2.94	3.61	4.26	4.87	5.46	6.02	6.56	7.08	7.57
	S	1.00	1.24	1.48	1.71	1.93	2.15	2.36	2.57	2.77
	r	1.23	1.23	1.22	1.21	1.21	1.20	1.19	1.19	1.18
	x	1.07	1.10	1.12	1.15	1.17	1.20	1.22	1.24	1.26
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	1.21	1.48	1.75	2.01	2.26	2.51	2.76	3.00	3.25
	r	0.79	0.78	0.78	0.78	0.78	0.77	0.77	0.77	0.77
	J	0.042	0.081	0.141	0.223	0.333	0.475	0.651	0.867	1.125
	Tools	Rolls	Rolls	Rolls	Rolls	Rolls	Rolls	Rolls		

Size	Legs	5 x 2½	5 x 3	5 x 3½					
	t	½	⅜	5/16	⅜	7/16	½	9/16	⅝
	Weight	4.24	3.45	3.09	3.69	4.27	4.84	5.40	5.95
	Area	3.50	2.85	2.56	3.05	3.53	4.00	4.46	4.92
	f_1	⅜	⅜	7/16	7/16	7/16	7/16	7/16	7/16
	f_2	¼	5/16	5/16	5/16	5/16	5/16	5/16	5/16
Axis X-X	I	8.74	7.15	6.39	7.56	8.69	9.77	10.82	11.82
	S	2.77	2.15	1.85	2.21	2.56	2.90	3.24	3.56
	r	1.58	1.59	1.58	1.58	1.57	1.56	1.56	1.55
	y	1.84	1.68	1.55	1.58	1.61	1.63	1.66	1.68
Axis Y-Y	I	1.46	1.93	2.58	3.04	3.49	3.91	4.32	4.70
	S	0.77	0.84	0.96	1.15	1.33	1.50	1.67	1.84
	r	0.64	0.82	1.00	1.00	0.99	0.99	0.98	0.98
	x	0.60	0.69	0.81	0.84	0.87	0.89	0.92	0.94
Axis Z-Z	Θ	14° 12′	19° 40′	25° 33′	25° 32′	25° 27′	25° 22′	25° 15′	25° 07′
	I	0.96	1.17	1.45	1.71	1.97	2.22	2.46	2.70
	r	0.52	0.64	0.75	0.75	0.75	0.74	0.74	0.74
	J	0.313	0.141	0.086	0.149	0.237	0.354	0.504	0.692
	Tools	734-DD	734-Q	Rolls	Rolls	Rolls	Rolls	Rolls	Rolls



ANGLES

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}

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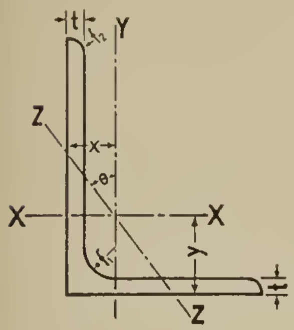
J = Torsion Factor in in.^{4}

Size	Legs	5 x 5						
	t	3/8	7/16	1/2	9/16	5/8	11/16	3/4
	Weight	4.36	5.05	5.74	6.42	7.08	7.74	8.39
	Area	3.60	4.18	4.74	5.30	5.85	6.40	6.93
	f_1	1/2	1/2	1/2	1/2	1/2	1/2	1/2
	f_2	3/8	3/8	3/8	3/8	3/8	3/8	3/8
Axis X-X	I	8.37	9.65	10.89	12.08	13.22	14.33	15.39
	S	2.30	2.67	3.03	3.39	3.73	4.07	4.41
	r	1.52	1.52	1.52	1.51	1.50	1.50	1.49
	y	1.36	1.38	1.41	1.43	1.46	1.48	1.51
Axis Y-Y	I	8.37	9.65	10.89	12.08	13.22	14.33	15.39
	S	2.30	2.67	3.03	3.39	3.73	4.07	4.41
	r	1.52	1.52	1.52	1.51	1.50	1.50	1.49
	x	1.36	1.38	1.41	1.43	1.46	1.48	1.51
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	3.44	3.96	4.47	4.97	5.47	5.96	6.44
	r	0.98	0.97	0.97	0.97	0.97	0.97	0.96
	J	0.176	0.279	0.417	0.593	0.814	1.08	1.41
	Tools	77-J	78-X					

Size	Legs	6 x 3½							
	t	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4
	Weight	3.49	4.15	4.81	5.46	6.10	6.73	7.35	7.95
	Area	2.88	3.43	3.98	4.51	5.04	5.56	6.07	6.57
	f_1	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
	f_2	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16
Axis X-X	I	10.64	12.60	14.50	16.34	18.11	19.83	21.49	23.09
	S	2.64	3.15	3.65	4.14	4.62	5.09	5.56	6.01
	r	1.92	1.92	1.91	1.90	1.90	1.89	1.88	1.87
	y	1.97	2.00	2.03	2.06	2.08	2.11	2.13	2.16
Axis Y-Y	I	2.70	3.19	3.66	4.11	4.53	4.94	5.33	5.71
	S	0.98	1.17	1.35	1.53	1.71	1.88	2.05	2.21
	r	0.97	0.96	0.96	0.95	0.95	0.94	0.94	0.93
	x	0.74	0.77	0.80	0.82	0.85	0.87	0.89	0.92
Axis Z-Z	Θ	18° 52′	18° 51′	18° 47′	18° 42′	18° 35′	18° 28′	18° 20′	18° 11′
	I	1.65	1.95	2.24	2.52	2.80	3.07	3.34	3.61
	r	0.76	0.75	0.75	0.75	0.75	0.74	0.74	0.74
	J	0.097	0.167	0.265	0.396	0.564	0.773	1.03	1.34
	Tools		734-R		734-9				



ANGLES

ELEMENTS OF SECTIONS

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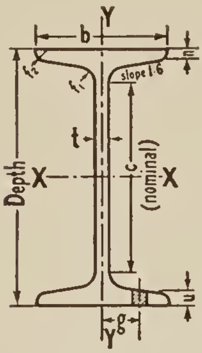
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}

Size		6 x 4						
Legs	t	3/8	7/16	1/2	9/16	5/8	11/16	3/4
Weight		4.36	5.05	5.74	6.42	7.08	7.74	8.39
Area		3.60	4.18	4.74	5.30	5.85	6.40	6.93
f_1		1/2	1/2	1/2	1/2	1/2	1/2	1/2
f_2		3/8	3/8	3/8	3/8	3/8	3/8	3/8
Axis X-X	I	13.02	15.02	16.95	18.82	20.63	22.39	24.08
	S	3.17	3.69	4.19	4.69	5.17	5.64	6.11
	r	1.90	1.90	1.89	1.88	1.88	1.87	1.86
	y	1.90	1.93	1.96	1.98	2.01	2.03	2.06
Axis Y-Y	I	4.63	5.34	6.01	6.65	7.27	7.86	8.43
	S	1.50	1.74	1.98	2.21	2.44	2.66	2.87
	r	1.13	1.13	1.13	1.12	1.11	1.11	1.10
	x	0.91	0.94	0.97	0.99	1.02	1.04	1.07
Axis Z-Z	Θ	23° 33′	23° 31′	23° 27′	23° 22′	23° 16′	23° 10′	23° 02′
	I	2.67	3.07	3.47	3.86	4.24	4.61	4.98
	r	0.86	0.86	0.86	0.85	0.85	0.85	0.85
J		0.176	0.279	0.417	0.593	0.814	1.08	1.41
Tools		Rolls	Rolls	Rolls	Rolls	Rolls	Rolls	

Size		6 x 6						
Legs	t	3/8	7/16	1/2	9/16	5/8	11/16	3/4
Weight		5.27	6.11	6.95	7.78	8.59	9.40	10.20
Area		4.35	5.05	5.74	6.43	7.10	7.77	8.43
f_1		1/2	1/2	1/2	1/2	1/2	1/2	1/2
f_2		3/8	3/8	3/8	3/8	3/8	3/8	3/8
Axis X-X	I	14.85	17.15	19.38	21.54	23.64	25.67	27.64
	S	3.38	3.93	4.46	4.99	5.51	6.02	6.52
	r	1.85	1.84	1.84	1.83	1.82	1.82	1.81
	y	1.60	1.63	1.66	1.68	1.71	1.73	1.76
Axis Y-Y	I	14.85	17.15	19.38	21.54	23.64	25.67	27.64
	S	3.38	3.93	4.46	4.99	5.51	6.02	6.52
	r	1.85	1.84	1.84	1.83	1.82	1.82	1.81
	x	1.60	1.63	1.66	1.68	1.71	1.73	1.76
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	6.07	7.01	7.92	8.82	9.70	10.57	11.43
	r	1.18	1.18	1.17	1.17	1.17	1.17	1.16
J		0.211	0.335	0.500	0.712	0.977	1.30	1.69
Tools		78-Q	78-V	78-S			78-W	



STANDARD I-BEAMS

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
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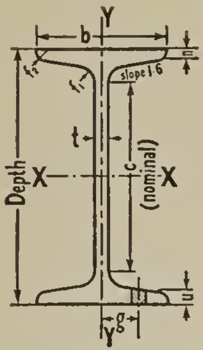
J = Torsion Factor in in.^{4}
Rivet given is maximum allowable in flange.
g = Usual gage.
u = Nominal grip.

Size	Depth	3			4			
	t	0.170	0.251	0.349	0.190	0.253	0.326	0.400
	Weight	2.02	2.31	2.67	2.72	3.03	3.38	3.74
	Area	1.67	1.91	2.21	2.25	2.50	2.79	3.09
	b	2.330	2.411	2.509	2.660	2.723	2.796	2.870
	n	0.170	0.170	0.170	0.190	0.190	0.190	0.190
	f_1	0.27	0.27	0.27	0.29	0.29	0.29	0.29
	f_2	0.10	0.10	0.10	0.11	0.11	0.11	0.11
	c	1¾	1¾	1¾	2¾	2¾	2¾	2¾
Axis X-X	I	2.52	2.71	2.93	6.06	6.40	6.79	7.18
	S	1.68	1.80	1.95	3.03	3.20	3.39	3.59
	r	1.23	1.19	1.15	1.64	1.60	1.56	1.52
Axis Y-Y	I	0.46	0.51	0.59	0.76	0.82	0.90	0.99
	S	0.39	0.42	0.47	0.57	0.61	0.65	0.69
	r	0.52	0.52	0.52	0.58	0.57	0.57	0.57
Rivet Data	Diam.	⅜	⅜	⅜	½	½	½	½
	g	¾	¾	¾	¾	¾	¾	¾
	u	5/16	5/16	5/16	5/16	5/16	5/16	5/16
	J	0.045	0.061	0.093	0.074	0.092	0.12	0.17
	Tools	851-A	851-J	851-D	851-B		851-F	

Size	Depth	5			6			7		
	t	0.210	0.347	0.494	0.230	0.343	0.465	0.250	0.345	0.450
	Weight	3.53	4.36	5.25	4.43	5.25	6.13	5.42	6.23	7.12
	Area	2.92	3.60	4.34	3.66	4.34	5.07	4.48	5.15	5.88
	b	3.000	3.137	3.284	3.330	3.443	3.565	3.660	3.755	3.860
	n	0.210	0.210	0.210	0.230	0.230	0.230	0.250	0.250	0.250
	f_1	0.31	0.31	0.31	0.33	0.33	0.33	0.35	0.35	0.35
	f_2	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15
	c	3½	3½	3½	4½	4½	4½	5¼	5¼	5¼
Axis X-X	I	12.26	13.69	15.22	22.08	24.11	26.31	36.69	39.40	42.40
	S	4.90	5.48	6.09	7.36	8.04	8.77	10.48	11.26	12.12
	r	2.05	1.95	1.87	2.46	2.36	2.28	2.86	2.77	2.69
Axis Y-Y	I	1.21	1.41	1.66	1.82	2.04	2.31	2.63	2.88	3.17
	S	0.81	0.90	1.01	1.09	1.19	1.30	1.44	1.53	1.64
	r	0.64	0.63	0.62	0.71	0.69	0.68	0.77	0.75	0.73
Rivet Data	Diam.	½	½	½	⅝	⅝	⅝	⅝	⅝	⅝
	g	⅞	⅞	⅞	1	1	1	1⅛	1⅛	1⅛
	u	⅜	⅜	⅜	⅜	⅜	⅜	⅜	⅜	⅜
	J	0.12	0.19	0.33	0.17	0.24	0.38	0.25	0.32	0.46
	Tools	851-C	851-E		851-K	851-L			851-H	



STANDARD I-BEAMS

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
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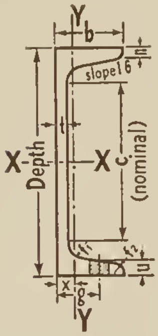
u = Nominal grip.

Size	Depth	8				9		
	t	0.270	0.349	0.441	0.532	0.290	0.397	0.561
	Weight	6.53	7.30	8.19	9.07	7.72	8.89	10.68
	Area	5.40	6.03	6.77	7.49	6.38	7.35	8.82
	b	4.000	4.079	4.171	4.262	4.330	4.437	4.601
	n	0.270	0.270	0.270	0.270	0.290	0.290	0.290
	f_1	0.37	0.37	0.37	0.37	0.39	0.39	0.39
	f_2	0.16	0.16	0.16	0.16	0.17	0.17	0.17
	c	$6\frac{1}{4}$	$6\frac{1}{4}$	$6\frac{1}{4}$	$6\frac{1}{4}$	7	7	7
Axis X-X	I	57.55	60.92	64.85	68.73	85.90	92.40	102.36
	S	14.39	15.23	16.21	17.18	19.09	20.53	22.75
	r	3.27	3.18	3.10	3.03	3.67	3.55	3.41
Axis Y-Y	I	3.73	3.99	4.31	4.66	5.09	5.54	6.30
	S	1.86	1.95	2.07	2.19	2.35	2.50	2.74
	r	0.83	0.81	0.80	0.79	0.89	0.87	0.85
Rivet Data	Diam.	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$
	g	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$
	u	$\frac{7}{16}$	$\frac{7}{16}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
	J	0.34	0.42	0.56	0.75	0.46	0.61	0.99
	Tools	851-G			851-M	851-N		

Size	Depth	10			12				
	t	0.310	0.447	0.594	0.350	0.428	0.460	0.565	0.687
	Weight	9.01	10.67	12.45	11.31	12.44	14.49	16.01	17.78
	Area	7.45	8.82	10.29	9.35	10.28	11.97	13.23	14.70
	b	4.660	4.797	4.944	5.000	5.078	5.250	5.355	5.477
	n	0.310	0.310	0.310	0.350	0.350	0.460	0.460	0.460
	f_1	0.41	0.41	0.41	0.45	0.45	0.56	0.56	0.56
	f_2	0.19	0.19	0.19	0.21	0.21	0.28	0.28	0.28
	c	8	8	8	$9\frac{3}{4}$	$9\frac{3}{4}$	$9\frac{1}{4}$	$9\frac{1}{4}$	$9\frac{1}{4}$
Axis X-X	I	123.39	134.81	147.06	218.13	229.36	272.15	287.27	304.84
	S	24.68	26.96	29.41	36.35	38.23	45.36	47.88	50.81
	r	4.07	3.91	3.78	4.83	4.72	4.77	4.66	4.56
Axis Y-Y	I	6.78	7.50	8.36	9.35	9.87	13.54	14.50	15.71
	S	2.91	3.13	3.38	3.74	3.89	5.16	5.42	5.74
	r	0.95	0.92	0.90	1.00	0.98	1.06	1.05	1.03
Rivet Data	Diam.	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$
	g	$1\frac{3}{8}$	$1\frac{3}{8}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{3}{4}$
	u	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{9}{16}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$
	J	0.62	0.86	1.31	0.92	1.10	1.78	2.19	2.85
	Tools								



STANDARD CHANNELS

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in $in.^4$
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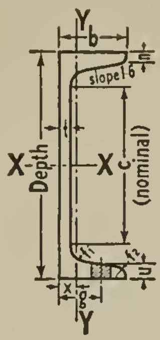
Rivet given is maximum allowable in flange.
g = Usual gage.
u = Nominal grip.

Size		3					4		
Size	Depth	3					4		
	t	0.170	0.187	0.258	0.320	0.356	0.180	0.247	0.320
Weight		1.46	1.52	1.78	2.00	2.13	1.90	2.22	2.58
Area		1.21	1.26	1.47	1.66	1.76	1.57	1.84	2.13
	b	1.410	1.427	1.498	1.560	1.596	1.580	1.647	1.720
	n	0.170	0.170	0.170	0.170	0.170	0.180	0.180	0.180
	f_1	0.27	0.27	0.27	0.27	0.27	0.28	0.28	0.28
	f_2	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11
	c	$1\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{3}{4}$
Axis X-X	I	1.66	1.69	1.85	1.99	2.07	3.83	4.19	4.58
Axis X-X	S	1.10	1.13	1.24	1.33	1.38	1.92	2.10	2.29
Axis X-X	r	1.17	1.16	1.12	1.10	1.08	1.56	1.51	1.47
Axis Y-Y	I	0.20	0.21	0.25	0.28	0.31	0.32	0.37	0.43
Axis Y-Y	S	0.20	0.21	0.23	0.25	0.27	0.28	0.31	0.34
Axis Y-Y	r	0.40	0.41	0.41	0.41	0.42	0.45	0.45	0.45
Axis Y-Y	x	0.44	0.44	0.44	0.45	0.46	0.46	0.45	0.46
Rivet Data	Diam.	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
Rivet Data	g	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	1	1	1
Rivet Data	u	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$
J		0.031	0.033	0.047	0.066	0.080	0.045	0.062	0.090
Tools		Rolls	Rolls	Rolls	Rolls	Rolls	Rolls	Rolls	Rolls

Size		5				6			
Size	Depth	5				6			
	t	0.190	0.225	0.325	0.472	0.200	0.225	0.314	0.437
Weight		2.38	2.59	3.20	4.09	2.91	3.09	3.73	4.63
Area		1.97	2.14	2.64	3.38	2.40	2.55	3.09	3.82
	b	1.750	1.785	1.885	2.032	1.920	1.945	2.034	2.157
	n	0.190	0.190	0.190	0.190	0.200	0.200	0.200	0.200
	f_1	0.29	0.29	0.29	0.29	0.30	0.30	0.30	0.30
	f_2	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12
	c	$3\frac{3}{4}$	$3\frac{3}{4}$	$3\frac{3}{4}$	$3\frac{3}{4}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$
Axis X-X	I	7.49	7.86	8.90	10.43	13.12	13.57	15.18	17.39
Axis X-X	S	3.00	3.14	3.56	4.17	4.37	4.52	5.06	5.80
Axis X-X	r	1.95	1.91	1.83	1.76	2.34	2.31	2.22	2.13
Axis Y-Y	I	0.48	0.52	0.63	0.81	0.69	0.73	0.87	1.05
Axis Y-Y	S	0.38	0.40	0.45	0.53	0.49	0.51	0.56	0.64
Axis Y-Y	r	0.49	0.49	0.49	0.49	0.54	0.54	0.53	0.52
Axis Y-Y	x	0.48	0.48	0.48	0.51	0.51	0.51	0.50	0.51
Rivet Data	Diam.	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{8}$
Rivet Data	g	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{3}{8}$
Rivet Data	u	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{3}{8}$
J		0.064	0.074	0.12	0.25	0.088	0.097	0.14	0.26
Tools		Rolls	Rolls	Rolls		852-F	Rolls	Rolls	Rolls



STANDARD CHANNELS

ELEMENTS OF SECTIONS

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Area in square inches.
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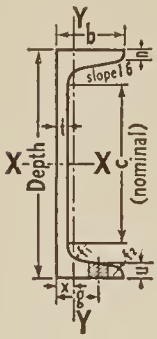
Size	Depth	7					8				
	t	0.210	0.230	0.314	0.419	0.524	0.250	0.303	0.395	0.487	0.520
Weight		3.47	3.64	4.36	5.24	6.13	4.38	4.89	5.78	6.67	6.99
Area		2.87	3.01	3.60	4.33	5.07	3.62	4.04	4.78	5.51	5.78
	b	2.090	2.110	2.194	2.299	2.404	2.290	2.343	2.435	2.527	2.560
	n	0.210	0.210	0.210	0.210	0.210	0.220	0.220	0.220	0.220	0.220
	f_1	0.31	0.31	0.31	0.31	0.31	0.32	0.32	0.32	0.32	0.32
	f_2	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
	c	5½	5½	5½	5½	5½	6½	6¼	6¼	6¼	6¼
Axis X-X	I	21.27	21.84	24.24	27.24	30.25	33.85	36.11	40.04	43.96	45.37
	S	6.08	6.24	6.93	7.78	8.64	8.46	9.03	10.01	10.99	11.34
	r	2.72	2.69	2.60	2.51	2.44	3.06	2.99	2.90	2.82	2.80
Axis Y-Y	I	0.97	1.01	1.17	1.38	1.59	1.40	1.53	1.75	1.98	2.07
	S	0.63	0.64	0.70	0.78	0.86	0.81	0.85	0.93	1.01	1.04
	r	0.58	0.58	0.57	0.56	0.56	0.62	0.61	0.61	0.60	0.60
	x	0.54	0.54	0.52	0.53	0.55	0.56	0.55	0.55	0.57	0.57
Rivet Data	Diam.	⅝	⅝	⅝	⅝	⅝	¾	¾	¾	¾	¾
	g	1¼	1¼	1¼	1¼	1½	1⅜	1⅜	1½	1½	1½
	u	⅜	7/16	⅜	7/16	7/16	⅜	⅜	7/16	7/16	7/16
J		0.12	0.13	0.18	0.29	0.47	0.17	0.21	0.32	0.47	0.55
Tools			Rolls	Rolls	Rolls	852-Q	Rolls	Rolls	Rolls	Rolls	Rolls

Size	Depth	9				10			
	t	0.230	0.285	0.448	0.612	0.240	0.379	0.526	0.673
Weight		4.74	5.34	7.11	8.90	5.43	7.11	8.89	10.67
Area		3.91	4.41	5.88	7.35	4.49	5.88	7.35	8.82
	b	2.430	2.485	2.648	2.812	2.600	2.739	2.886	3.033
	n	0.230	0.230	0.230	0.230	0.240	0.240	0.240	0.240
	f_1	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.34
	f_2	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
	c	7¼	7¼	7¼	7¼	8¼	8¼	8¼	8¼
Axis X-X	I	47.68	51.02	60.92	70.89	67.37	78.95	91.20	103.45
	S	10.60	11.34	13.54	15.75	13.47	15.79	18.24	20.69
	r	3.49	3.40	3.22	3.11	3.87	3.66	3.52	3.43
Axis Y-Y	I	1.75	1.93	2.42	2.94	2.28	2.81	3.36	3.95
	S	0.96	1.01	1.17	1.34	1.16	1.32	1.48	1.66
	r	0.67	0.66	0.64	0.63	0.71	0.69	0.68	0.67
	x	0.60	0.59	0.58	0.61	0.63	0.61	0.62	0.65
Rivet Data	Diam.	¾	¾	¾	¾	¾	¾	¾	¾
	g	1⅜	1⅜	1½	1½	1½	1½	1¾	1¾
	u	7/16	7/16	½	½	7/16	7/16	½	½
J		0.20	0.24	0.47	0.92	0.25	0.41	0.75	1.32
Tools		852-R		852-T	852-U	852-P			

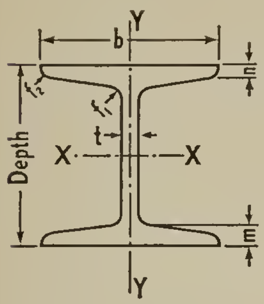


STANDARD CHANNELS

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}
Rivet given is maximum allowable in flange.
g = Usual gage.
u = Nominal grip.

Size	Depth	12			
	t	0.280	0.387	0.510	0.632
	Weight Area	7.33 6.06	8.89 7.35	10.67 8.82	12.45 10.29
	b n f_1 f_2 c	2.940 0.280 0.38 0.17 10	3.047 0.280 0.38 0.17 10	3.170 0.280 0.38 0.17 10	3.292 0.280 0.38 0.17 10
Axis X-X	I S r	128.96 21.49 4.61	144.37 24.06 4.43	162.08 27.01 4.29	179.65 29.94 4.18
Axis Y-Y	I S r x	3.87 1.73 0.80 0.70	4.47 1.89 0.78 0.67	5.14 2.06 0.76 0.67	5.82 2.24 0.75 0.69
Rivet Data	Diam. g u	7/8 1 3/4 1/2	7/8 1 3/4 1/2	7/8 1 3/4 1/2	7/8 2 5/8
	J	0.43	0.61	0.95	1.48
	Tools	Rolls	Rolls	Rolls	Rolls

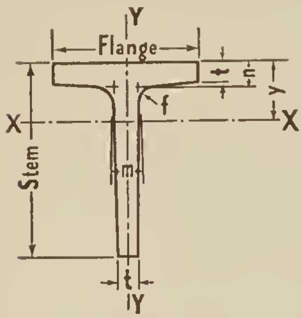


H-BEAMS

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}

Size	Depth	4	5	6			8		
	t	0.313	0.313	0.250	0.313	0.438	0.313	0.375	0.500
Weight		4.85	6.63	8.04	8.49	9.40	11.51	12.11	13.32
Area		4.00	5.48	6.64	7.02	7.77	9.52	10.01	11.01
b		4.000	5.000	5.938	6.000	6.125	7.938	8.000	8.125
m		0.453	0.503	0.542	0.542	0.542	0.560	0.560	0.560
n		0.290	0.330	0.360	0.360	0.360	0.358	0.358	0.358
f_1		0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313
f_2		0.145	0.165	0.180	0.180	0.180	0.179	0.179	0.179
Axis X-X	I	10.72	23.82	44.06	45.19	47.44	112.94	115.58	120.92
	S	5.36	9.53	14.69	15.06	15.81	28.23	28.90	30.23
	r	1.64	2.08	2.58	2.54	2.47	3.45	3.40	3.31
Axis Y-Y	I	3.56	7.82	14.18	14.65	15.65	34.15	35.01	36.79
	S	1.78	3.13	4.77	4.88	5.11	8.60	8.75	9.06
	r	0.94	1.19	1.46	1.44	1.42	1.89	1.87	1.83
J		0.22	0.34	0.45	0.50	0.62	0.68	0.75	0.96
Tools		3002-A	3002-B	3002-C			3002-D		



TEES

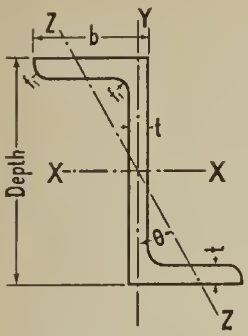
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.

I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.

Size	Flange	1	1½					2		2¼	2½		
	Stem	1	1¼	1¼	1½	1½	2	2	2	2¼	1¼	2½	3
	t	⅛	⅛	3/16	3/16	¼	3/16	¼	5/16	¼	3/16	5/16	5/16
	Weight	0.323	0.451	0.633	0.704	0.895	0.884	1.29	1.55	1.47	1.03	1.97	2.17
	Area	0.267	0.373	0.523	0.581	0.740	0.730	1.07	1.28	1.21	0.85	1.62	1.80
	m	5/32	5/32	7/32	7/32	9/32	¼	5/16	⅜	5/16	5/16	⅜	⅜
	n	5/32	5/32	7/32	7/32	9/32	¼	5/16	⅜	5/16	9/32	⅜	⅜
	f	⅛	⅛	⅛	3/16	3/16	3/16	¼	¼	¼	3/16	¼	¼
Axis X-X	I	0.023	0.049	0.067	0.114	0.142	0.269	0.37	0.43	0.53	0.08	0.89	1.49
	S	0.032	0.053	0.075	0.108	0.137	0.195	0.26	0.31	0.33	0.09	0.50	0.72
	r	0.293	0.363	0.359	0.443	0.438	0.606	0.59	0.58	0.66	0.31	0.74	0.91
	y	0.292	0.326	0.352	0.437	0.464	0.624	0.58	0.61	0.64	0.30	0.73	0.92
Axis Y-Y	I	0.011	0.038	0.056	0.056	0.075	0.060	0.18	0.23	0.26	0.28	0.44	0.44
	S	0.023	0.051	0.075	0.075	0.100	0.080	0.18	0.23	0.23	0.22	0.35	0.35
	r	0.206	0.319	0.328	0.312	0.319	0.286	0.41	0.42	0.46	0.57	0.52	0.50
	Tools	853-F	853-B	853-N	853-K	853-G		853-C		853-J	853-A	853-M	853-P

Size	Flange	3			4							4½	5
	Stem	2½	3	3	2	2½	3	4	4½	5	5	3	3
	t	5/16	5/16	⅜	⅜	5/16	5/16	⅜	⅜	⅜	½	5/16	⅜
	Weight	2.19	2.40	2.79	2.78	2.63	2.84	3.85	4.10	4.34	5.56	3.04	4.14
	Area	1.81	1.98	2.31	2.30	2.17	2.34	3.18	3.39	3.59	4.60	2.52	3.42
	m	⅜	⅜	7/16	7/16	⅜	⅜	7/16	7/16	7/16	9/16	⅜	⅝
	n	⅜	⅜	7/16	7/16	⅜	⅜	7/16	7/16	7/16	9/16	⅜	7/16
	f	5/16	5/16	5/16	¼	⅜	⅜	½	½	½	½	⅜	⅜
Axis X-X	I	0.94	1.58	1.83	0.60	1.01	1.72	4.56	6.37	8.56	10.84	1.78	2.37
	S	0.51	0.74	0.86	0.40	0.53	0.77	1.58	1.98	2.43	3.14	0.78	1.06
	r	0.72	0.89	0.89	0.51	0.68	0.86	1.20	1.37	1.54	1.54	0.84	0.83
	y	0.68	0.85	0.88	0.48	0.60	0.75	1.11	1.29	1.48	1.54	0.71	0.76
Axis Y-Y	I	0.75	0.75	0.90	2.10	1.77	1.77	2.12	2.13	2.13	2.83	2.52	4.13
	S	0.50	0.50	0.60	1.05	0.88	0.89	1.06	1.06	1.06	1.42	1.12	1.65
	r	0.65	0.62	0.63	0.96	0.90	0.87	0.82	0.79	0.77	0.79	1.00	1.10
	Tools	853-H		853-D	853-L		853-R	853-E		853-S	853-T	853-O	853-Q



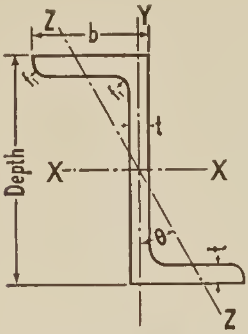
ZEES

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.⁴
S = Section Modulus in in.³
r = Radius of Gyration in inches.
J = Torsion Factor in in.⁴

Size	Nominal depth	1¾	2	2⅜	3					
	t	3/16	3/16	3/16	¼	5/16	⅜	7/16	½	9/16
	Weight	1.116	0.946	1.031	2.40	3.02	3.48	4.09	4.48	5.08
	Area	0.922	0.782	0.852	1.98	2.50	2.87	3.38	3.70	4.20
	Actual depth	1¾	2	2⅜	3	3 1/16	3	3 1/16	3	3 1/16
	b	1¾	1¼	1¼	2 11/16	2¾	2 11/16	2¾	2 11/16	2¾
	f_1	3/16	3/16	3/16	5/16	5/16	5/16	5/16	5/16	5/16
	f_2	⅛	⅛	⅛	¼	¼	¼	¼	¼	¼
Axis X-X	I	0.446	0.458	0.694	2.89	3.65	3.86	4.57	4.60	5.26
	S	0.510	0.458	0.584	1.92	2.39	2.57	2.99	3.06	3.44
	r	0.695	0.765	0.902	1.21	1.21	1.16	1.16	1.11	1.12
Axis Y-Y	I	0.551	0.186	0.186	2.64	3.47	3.76	4.59	4.71	5.53
	S	0.333	0.161	0.161	1.03	1.34	1.50	1.81	1.93	2.24
	r	0.773	0.488	0.467	1.15	1.18	1.14	1.17	1.13	1.15
Axis Z-Z	Θ	48° 49′	29° 12′	23° 12′	43° 24′	44° 05′	44° 31′	45° 04′	45° 27′	45° 55′
	I	0.101	0.063	0.082	0.59	0.76	0.82	0.99	1.03	1.22
	r	0.331	0.283	0.310	0.54	0.55	0.53	0.54	0.53	0.54
	J	0.012	0.010	0.011	0.044	0.087	0.15	0.24	0.35	0.51
	Tools	771-D	771-C	7088	771-B		771-A			

Size	Nominal depth	4					
	t	¼	5/16	⅜	7/16	½	9/16
	Weight	2.93	3.68	4.44	4.92	5.65	6.40
	Area	2.42	3.04	3.67	4.06	4.67	5.29
	Actual depth	4	4 1/16	4⅛	4	4 1/16	4⅛
	b	3 1/16	3⅛	3 3/16	3 1/16	3⅛	3 3/16
	f_1	5/16	5/16	5/16	5/16	5/16	5/16
	f_2	¼	¼	¼	¼	¼	¼
Axis X-X	I	6.32	7.97	9.66	9.68	11.20	12.76
	S	3.16	3.92	4.68	4.84	5.51	6.19
	r	1.62	1.62	1.62	1.54	1.55	1.55
Axis Y-Y	I	4.01	5.24	6.54	6.53	7.75	9.05
	S	1.36	1.76	2.18	2.30	2.70	3.11
	r	1.29	1.31	1.33	1.27	1.29	1.31
Axis Z-Z	Θ	36° 47′	37° 24′	37° 55′	37° 50′	38° 16′	38° 41′
	I	1.08	1.39	1.72	1.74	2.06	2.41
	r	0.67	0.68	0.68	0.66	0.66	0.68
	J	0.053	0.10	0.18	0.28	0.43	0.62
	Tools	Rolls	Rolls	Rolls	771-G		771-F



ZEES

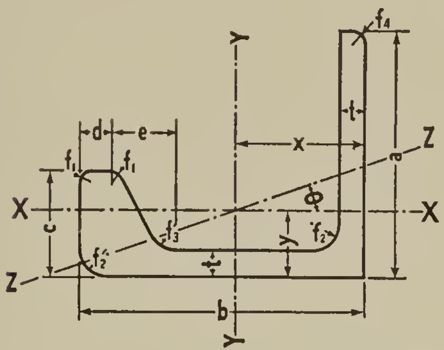
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}

Size		5					
Nominal depth	t	5/16	3/8	7/16	1/2	9/16	5/8
Weight		4.13	4.98	5.84	6.37	7.21	8.05
Area		3.41	4.12	4.83	5.27	5.96	6.66
Actual depth		5	5 1/16	5 1/8	5	5 1/16	5 1/8
b		3 1/4	3 5/16	3 3/8	3 1/4	3 5/16	3 3/8
f_1		5/16	5/16	5/16	5/16	5/16	5/16
f_2		1/4	1/4	1/4	1/4	1/4	1/4
Axis X-X	I	13.41	16.23	19.12	19.23	21.87	24.56
	S	5.36	6.41	7.46	7.69	8.64	9.59
	r	1.98	1.99	1.99	1.91	1.92	1.92
Axis Y-Y	I	5.94	7.40	8.95	8.82	10.28	11.82
	S	1.92	2.37	2.84	2.94	3.39	3.86
	r	1.32	1.34	1.36	1.29	1.31	1.33
Axis Z-Z	Θ	30° 40′	31° 08′	31° 32′	31° 09′	31° 32′	31° 53′
	I	1.89	2.33	2.81	2.82	3.29	3.79
	r	0.74	0.75	0.76	0.73	0.74	0.75
J		0.12	0.21	0.33	0.48	0.69	0.97
Tools			771-E		771-H		

Size		6					
Nominal depth	t	3/8	7/16	1/2	9/16	5/8	11/16
Weight		5.58	6.54	7.51	8.10	9.05	10.00
Area		4.61	5.40	6.20	6.69	7.48	8.27
Actual depth		6	6 1/16	6 1/8	6	6 1/16	6 1/8
b		3 1/2	3 9/16	3 5/8	3 1/2	3 9/16	3 5/8
f_1		5/16	5/16	5/16	5/16	5/16	5/16
f_2		1/4	1/4	1/4	1/4	1/4	1/4
Axis X-X	I	25.40	29.88	34.44	34.71	38.93	43.24
	S	8.47	9.86	11.24	11.57	12.84	14.12
	r	2.35	2.35	2.36	2.28	2.28	2.29
Axis Y-Y	I	8.83	10.66	12.58	12.32	14.15	16.07
	S	2.67	3.19	3.73	3.83	4.35	4.90
	r	1.38	1.40	1.42	1.36	1.38	1.39
Axis Z-Z	Θ	26° 55′	27° 17′	27° 37′	27° 08′	27° 26′	27° 44′
	I	3.08	3.70	4.36	4.36	5.01	5.70
	r	0.82	0.83	0.84	0.81	0.82	0.83
J		0.23	0.37	0.56	0.77	1.07	1.45
Tools							

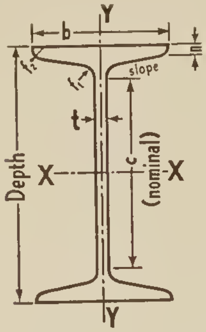
BULB ANGLE



ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.

Size	Legs	4 x 3½
	t	⅜
Weight		4.32
Area		3.57
a		3.50
b		4.00
c		1.50
d		7/16
e		13/16
f_1		⅛
f_2		⅜
f_3		¼
f_4		3/16
Axis X-X	I	3.02
	S	1.18
	r	0.92
	y	0.93
Axis Y-Y	I	7.95
	S	3.58
	r	1.49
	x	1.78
Axis Z-Z	Θ	20° 13′
	I	2.24
	r	0.79
Tools		5022

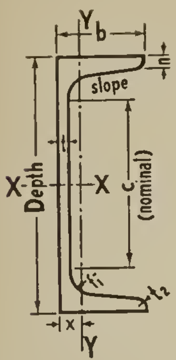


SPECIAL I-BEAMS

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}
Rivet given is maximum allowable in flange.
g = Usual gage.
u = Nominal grip.

Size	Depth	2		2½
	t	0.094	0.188	0.250
	Weight	0.804	1.473	1.850
	Area	0.664	1.217	1.529
	b	2.00	2.00	2.00
	Slope	0	1:11.4	1:7
	n	0.125	0.188	0.188
	f_1	0.125	0.188	0.250
	f_2	0.125	0.094	0.125
	c	1½	1⅛	1⅜
Axis X-X	I	0.481	0.782	1.453
	S	0.481	0.782	1.162
	r	0.85	0.80	0.97
Axis Y-Y	I	0.154	0.275	0.292
	S	0.154	0.275	0.292
	r	0.48	0.47	0.44
	J	0.004	0.025	0.091
	Tools	8606	10096	4465



SPECIAL CHANNELS

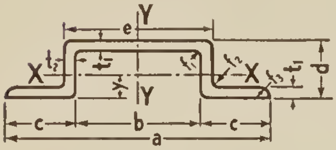
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}

Size	Depth	2	2½	3		4	5		
	t	0.170	0.250	0.250	0.375	0.318	0.188	0.500	0.438
	Weight	1.253	1.277	2.30	2.78	3.41	3.19	4.88	5.99
	Area	1.036	1.055	1.90	2.30	2.82	2.64	4.03	4.95
	b	1.41	1.250	2.000	2.000	2.500	2.875	2.500	2.875
	Slope	1:6.0	1:6.0	1:12.1	0	1:34.9	1:10.7	0	1:9.8
	n	0.170	0.125	0.250	0.375	0.313	0.188	0.375	0.438
	f_1	0.270	0.250	0.250	0.188	0.375	0.250	0.375	0.250
	f_2	0.100	0.125	0	0.375	0.125	0.094	0.250	0.094
	c	¾	1⅜	1¾	1¾	2⅜	3½	3½	3
Axis X-X	I	0.621	0.879	2.61	2.89	6.84	11.20	13.37	18.13
	S	0.621	0.703	1.74	1.92	3.42	4.48	5.35	7.25
	r	0.775	0.913	1.17	1.12	1.56	2.06	1.82	1.91
Axis Y-Y	I	0.172	0.111	0.68	0.78	1.62	1.91	1.94	3.57
	S	0.188	0.122	0.52	0.59	0.95	0.96	1.08	1.87
	r	0.407	0.324	0.60	0.58	0.76	0.85	0.69	0.85
	x	0.494	0.344	0.68	0.67	0.81	0.89	0.71	0.96
	J	0.029	0.025	0.068	0.12	0.50	0.18	0.30	0.55
	Tools	852-H	7400	5287	2229	4885	1351	1665	1052

Size	Depth	6		8		10		
	t	0.500	0.375	0.380	0.425	0.375	0.438	0.500
	Weight	5.94	6.10	6.62	8.09	8.84	9.59	10.34
	Area	4.91	5.04	5.47	6.68	7.30	7.93	8.55
	b	3.000	3.500	3.000	3.500	3.500	3.563	3.625
	Slope	0	1:49.6	1:14.4	1:28.5	1:9	1:9	1:9
	n	0.375	0.412	0.380	0.471	0.375	0.375	0.375
	f_1	0.375	0.480	0.550	0.525	0.625	0.625	0.625
	f_2	0.250	0.420	0.200	0.375	0.188	0.188	0.188
	c	4½	4	5¾	5¾	7½	7½	7½
Axis X-X	I	24.05	28.22	50.44	63.76	109.62	114.87	120.03
	S	8.02	9.41	12.61	15.94	21.92	22.97	24.01
	r	2.21	2.37	3.04	3.09	3.88	3.81	3.75
Axis Y-Y	I	3.52	5.58	3.49	7.06	7.19	7.73	8.25
	S	1.61	2.31	1.56	2.84	2.80	2.93	3.04
	r	0.85	1.05	0.80	1.03	0.99	0.99	0.98
	x	0.81	1.09	0.76	1.01	0.93	0.92	0.91
	J	0.36	0.32	0.38	0.56	0.66	0.78	0.94
	Tools	1666	2658	11866	10005	Rolls	Rolls	Rolls

WING CHANNELS

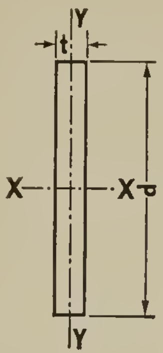


ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.

I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.

	Width, a	3 1/2	4			4 3/4	5		7 1/2	8 3/4
	Weight	0.537	0.794	0.925	1.173	1.30	1.15	1.90	4.97	5.02
	Area	0.444	0.656	0.765	0.969	1.08	0.95	1.57	4.11	4.15
	b	2 1/16	1 3/4	1 3/4	1 5/16	2	2 3/4	1 5/8	2 1/8	4 1/8
	c	23/32	1 1/8	1 1/8	1 11/32	1 3/8	1 1/8	1 11/16	2 11/16	2 5/16
	Depth, d	3/4	3/4	1 1/8	2	2	1 1/2	1 7/8	3 3/8	3 1/8
	e	2 1/4	2	2	1 1/2	2 1/4	3	2	2 3/4	4 5/8
	Thickness, t_1	3/32	1/8	1/8	5/32	1/8	1/8	3/16	5/16	5/16
	Thickness, t_2	3/32	1/8	1/8	3/32	1/8	1/8	3/16	5/16	1/4
	f_1	3/32	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8
	f_2	3/32	1/8	3/16	0	1/8	3/16	1/4	1/8	1/8
	f_3	0	1/8	1/32	1/8	0	0	1/8	0	1/8
Axis X-X	I	0.038	0.054	0.148	0.603	0.668	0.339	0.778	6.28	6.40
	S	0.116	0.139	0.251	0.517	0.634	0.485	0.709	3.15	4.10
	r	0.293	0.288	0.440	0.789	0.788	0.597	0.704	1.24	1.24
	y	0.420	0.359	0.533	0.833	0.946	0.803	0.778	1.38	1.56
Axis Y-Y	I	0.484	0.804	0.946	0.980	1.69	1.97	2.53	13.66	24.23
	S	0.276	0.402	0.473	0.490	0.71	0.79	1.01	3.64	5.54
	r	1.044	1.107	1.112	1.006	1.25	1.44	1.27	1.82	2.42
	Tools	9004	7838	4277	8604	9498	4619	5899	5023	8073



RECTANGLES

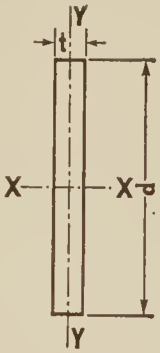
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
1	Wt.	0.151	0.227	0.303	0.378	0.454	0.529	0.605	0.681	0.756	0.908	1.059	1.210
	Area	0.125	0.188	0.250	0.313	0.375	0.438	0.500	0.563	0.625	0.750	0.875	1.000
	I x-x	0.010	0.016	0.021	0.026	0.031	0.037	0.042	0.047	0.052	0.063	0.073	0.083
	I y-y	0.000	0.001	0.001	0.003	0.004	0.007	0.010	0.015	0.020	0.035	0.056	0.083
1⅛	Wt.	0.170	0.255	0.340	0.425	0.510	0.596	0.681	0.766	0.851	1.021	1.191	1.361
	Area	0.141	0.211	0.281	0.352	0.422	0.492	0.563	0.633	0.703	0.844	0.984	1.125
	I x-x	0.015	0.022	0.030	0.037	0.045	0.052	0.059	0.067	0.074	0.089	0.104	0.119
	I y-y	0.000	0.001	0.001	0.003	0.005	0.008	0.012	0.017	0.023	0.040	0.063	0.094
1¼	Wt.	0.189	0.284	0.378	0.473	0.567	0.662	0.756	0.851	0.945	1.134	1.324	1.513
	Area	0.156	0.234	0.313	0.391	0.469	0.547	0.625	0.703	0.781	0.938	1.094	1.250
	I x-x	0.020	0.031	0.041	0.051	0.061	0.071	0.081	0.092	0.102	0.122	0.142	0.163
	I y-y	0.000	0.001	0.002	0.003	0.005	0.009	0.013	0.019	0.025	0.044	0.070	0.104
1⅜	Wt.	0.208	0.312	0.416	0.520	0.624	0.728	0.832	0.936	1.040	1.248	1.456	1.664
	Area	0.172	0.258	0.344	0.430	0.516	0.602	0.688	0.773	0.859	1.031	1.203	1.375
	I x-x	0.027	0.041	0.054	0.068	0.081	0.095	0.108	0.122	0.135	0.163	0.190	0.217
	I y-y	0.000	0.001	0.002	0.003	0.006	0.010	0.014	0.020	0.028	0.048	0.077	0.115
1½	Wt.	0.227	0.340	0.454	0.567	0.681	0.794	0.908	1.021	1.134	1.361	1.588	1.815
	Area	0.188	0.281	0.375	0.469	0.563	0.656	0.750	0.844	0.938	1.125	1.313	1.500
	I x-x	0.035	0.053	0.070	0.088	0.106	0.123	0.141	0.158	0.176	0.211	0.246	0.281
	I y-y	0.000	0.001	0.002	0.004	0.007	0.010	0.016	0.022	0.031	0.053	0.084	0.125
1⅝	Wt.	0.246	0.369	0.492	0.614	0.737	0.860	0.983	1.106	1.229	1.475	1.720	1.966
	Area	0.203	0.305	0.406	0.508	0.609	0.711	0.813	0.914	1.016	1.219	1.422	1.625
	I x-x	0.045	0.067	0.089	0.112	0.134	0.156	0.179	0.201	0.224	0.268	0.313	0.358
	I y-y	0.000	0.001	0.002	0.004	0.007	0.011	0.017	0.024	0.033	0.057	0.091	0.135
1¾	Wt.	0.265	0.397	0.529	0.662	0.794	0.926	1.059	1.191	1.323	1.588	1.853	2.118
	Area	0.219	0.328	0.438	0.547	0.656	0.766	0.875	0.984	1.094	1.313	1.531	1.750
	I x-x	0.056	0.084	0.112	0.140	0.168	0.195	0.223	0.251	0.279	0.335	0.391	0.447
	I y-y	0.000	0.001	0.002	0.004	0.008	0.012	0.018	0.026	0.036	0.062	0.098	0.146
1⅞	Wt.	0.284	0.425	0.567	0.709	0.851	0.993	1.134	1.276	1.418	1.702	1.985	2.269
	Area	0.234	0.352	0.469	0.586	0.703	0.820	0.938	1.055	1.172	1.406	1.641	1.875
	I x-x	0.069	0.103	0.137	0.172	0.206	0.240	0.275	0.309	0.343	0.412	0.481	0.549
	I y-y	0.000	0.001	0.002	0.005	0.008	0.013	0.020	0.028	0.038	0.066	0.105	0.156



RECTANGLES

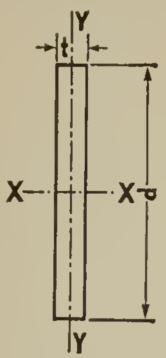
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
2	Wt.	0.303	0.454	0.605	0.756	0.908	1.059	1.210	1.361	1.513	1.815	2.118	2.420
	Area	0.250	0.375	0.500	0.625	0.750	0.875	1.000	1.125	1.250	1.500	1.750	2.000
	I x-x	0.083	0.125	0.167	0.208	0.250	0.292	0.333	0.375	0.417	0.500	0.583	0.667
	I y-y	0.000	0.001	0.003	0.005	0.009	0.014	0.021	0.030	0.041	0.070	0.112	0.167
2 1/8	Wt.	0.321	0.482	0.643	0.804	0.964	1.125	1.286	1.446	1.607	1.928	2.250	2.571
	Area	0.266	0.398	0.531	0.664	0.797	0.930	1.063	1.195	1.328	1.594	1.859	2.125
	I x-x	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.450	0.500	0.600	0.700	0.800
	I y-y	0.000	0.001	0.003	0.005	0.009	0.015	0.022	0.032	0.043	0.075	0.119	0.177
2 1/4	Wt.	0.340	0.510	0.681	0.851	1.021	1.191	1.361	1.531	1.702	2.042	2.382	2.723
	Area	0.281	0.422	0.563	0.703	0.844	0.984	1.125	1.266	1.406	1.688	1.969	2.250
	I x-x	0.119	0.178	0.237	0.297	0.356	0.415	0.475	0.534	0.593	0.712	0.831	0.949
	I y-y	0.000	0.001	0.003	0.006	0.010	0.016	0.023	0.033	0.046	0.079	0.126	0.187
2 3/8	Wt.	0.359	0.539	0.718	0.898	1.078	1.257	1.437	1.616	1.796	2.155	2.515	2.874
	Area	0.297	0.445	0.594	0.742	0.891	1.039	1.188	1.336	1.484	1.781	2.078	2.375
	I x-x	0.140	0.209	0.279	0.349	0.419	0.488	0.558	0.628	0.698	0.837	0.977	1.116
	I y-y	0.000	0.001	0.003	0.006	0.010	0.017	0.025	0.035	0.048	0.083	0.133	0.198
2 1/2	Wt.	0.378	0.567	0.756	0.945	1.134	1.323	1.513	1.702	1.891	2.269	2.647	3.025
	Area	0.313	0.469	0.625	0.781	0.938	1.094	1.250	1.406	1.563	1.875	2.188	2.500
	I x-x	0.163	0.244	0.326	0.407	0.488	0.570	0.651	0.732	0.814	0.977	1.139	1.302
	I y-y	0.000	0.001	0.003	0.006	0.011	0.017	0.026	0.037	0.051	0.088	0.140	0.208
2 5/8	Wt.	0.397	0.596	0.794	0.993	1.191	1.390	1.588	1.787	1.985	2.382	2.779	3.176
	Area	0.328	0.492	0.656	0.820	0.984	1.148	1.313	1.477	1.641	1.969	2.297	2.625
	I x-x	0.188	0.283	0.377	0.471	0.565	0.660	0.754	0.848	0.942	1.131	1.319	1.507
	I y-y	0.000	0.001	0.003	0.007	0.012	0.018	0.027	0.039	0.053	0.092	0.147	0.219
2 3/4	Wt.	0.416	0.624	0.832	1.040	1.248	1.456	1.664	1.872	2.080	2.496	2.912	3.328
	Area	0.344	0.516	0.688	0.859	1.031	1.203	1.375	1.547	1.719	2.063	2.406	2.750
	I x-x	0.217	0.325	0.433	0.542	0.650	0.758	0.867	0.975	1.083	1.300	1.517	1.733
	I y-y	0.000	0.002	0.004	0.007	0.012	0.019	0.029	0.041	0.056	0.097	0.154	0.229
2 7/8	Wt.	0.435	0.652	0.870	1.087	1.305	1.522	1.739	1.957	2.174	2.609	3.044	3.479
	Area	0.359	0.539	0.719	0.898	1.078	1.258	1.438	1.617	1.797	2.156	2.516	2.875
	I x-x	0.248	0.371	0.495	0.619	0.743	0.866	0.990	1.114	1.238	1.485	1.733	1.980
	I y-y	0.000	0.002	0.004	0.007	0.013	0.020	0.030	0.043	0.058	0.101	0.161	0.240



RECTANGLES

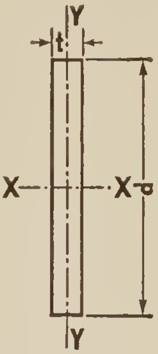
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		⅛	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1
3	Wt.	0.454	0.681	0.908	1.134	1.361	1.588	1.815	2.042	2.269	2.723	3.176	3.630
	Area	0.375	0.563	0.750	0.938	1.125	1.313	1.500	1.688	1.875	2.250	2.625	3.000
	I x-x	0.281	0.422	0.563	0.703	0.844	0.984	1.125	1.266	1.406	1.688	1.969	2.250
	I y-y	0.000	0.002	0.004	0.008	0.013	0.021	0.031	0.044	0.061	0.105	0.167	0.250
3⅛	Wt.	0.473	0.709	0.945	1.182	1.418	1.654	1.891	2.127	2.363	2.836	3.309	3.781
	Area	0.391	0.586	0.781	0.977	1.172	1.367	1.563	1.758	1.953	2.344	2.734	3.125
	I x-x	0.318	0.477	0.636	0.795	0.954	1.113	1.272	1.431	1.590	1.907	2.225	2.543
	I y-y	0.001	0.002	0.004	0.008	0.014	0.022	0.033	0.046	0.064	0.110	0.174	0.260
3¼	Wt.	0.492	0.737	0.983	1.229	1.475	1.720	1.966	2.212	2.458	2.949	3.441	3.933
	Area	0.406	0.609	0.813	1.016	1.219	1.422	1.625	1.828	2.031	2.438	2.844	3.250
	I x-x	0.358	0.536	0.715	0.894	1.073	1.252	1.430	1.609	1.788	2.146	2.503	2.861
	I y-y	0.001	0.002	0.004	0.008	0.014	0.023	0.034	0.048	0.066	0.114	0.181	0.271
3⅜	Wt.	0.510	0.766	1.021	1.276	1.531	1.787	2.042	2.297	2.552	3.063	3.573	4.084
	Area	0.422	0.633	0.844	1.055	1.266	1.477	1.688	1.898	2.109	2.531	2.953	3.375
	I x-x	0.401	0.601	0.801	1.001	1.201	1.402	1.602	1.802	2.002	2.403	2.803	3.204
	I y-y	0.001	0.002	0.004	0.009	0.015	0.024	0.035	0.050	0.069	0.119	0.188	0.281
3½	Wt.	0.529	0.794	1.059	1.323	1.588	1.853	2.118	2.382	2.647	3.176	3.706	4.235
	Area	0.438	0.656	0.875	1.094	1.313	1.531	1.750	1.969	2.188	2.625	3.063	3.500
	I x-x	0.447	0.670	0.893	1.117	1.340	1.563	1.787	2.010	2.233	2.680	3.126	3.573
	I y-y	0.001	0.002	0.005	0.009	0.015	0.024	0.036	0.052	0.071	0.123	0.195	0.292
3⅝	Wt.	0.548	0.822	1.097	1.371	1.645	1.919	2.193	2.467	2.741	3.290	3.838	4.386
	Area	0.453	0.680	0.906	1.133	1.359	1.586	1.813	2.039	2.266	2.719	3.172	3.625
	I x-x	0.496	0.744	0.992	1.241	1.489	1.737	1.985	2.233	2.481	2.977	3.473	3.970
	I y-y	0.001	0.002	0.005	0.009	0.016	0.025	0.038	0.054	0.074	0.127	0.202	0.302
3¾	Wt.	0.567	0.851	1.134	1.418	1.702	1.985	2.269	2.552	2.836	3.403	3.971	4.538
	Area	0.469	0.703	0.938	1.172	1.406	1.641	1.875	2.109	2.344	2.813	3.281	3.750
	I x-x	0.549	0.824	1.099	1.373	1.648	1.923	2.197	2.472	2.747	3.296	3.845	4.395
	I y-y	0.001	0.002	0.005	0.010	0.016	0.026	0.039	0.056	0.076	0.132	0.209	0.312
3⅞	Wt.	0.586	0.879	1.172	1.465	1.758	2.051	2.344	2.637	2.930	3.517	4.103	4.689
	Area	0.484	0.727	0.969	1.211	1.453	1.695	1.938	2.180	2.422	2.906	3.391	3.875
	I x-x	0.606	0.909	1.212	1.515	1.818	2.121	2.424	2.728	3.031	3.637	4.243	4.849
	I y-y	0.001	0.002	0.005	0.010	0.017	0.027	0.040	0.057	0.079	0.136	0.216	0.323



RECTANGLES

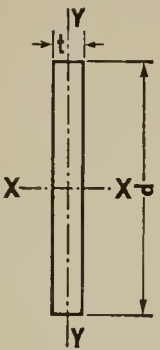
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
4	Wt.	0.605	0.908	1.210	1.513	1.815	2.118	2.420	2.723	3.025	3.630	4.235	4.840
	Area	0.500	0.750	1.000	1.250	1.500	1.750	2.000	2.250	2.500	3.000	3.500	4.000
	I x-x	0.667	1.000	1.333	1.667	2.000	2.333	2.667	3.000	3.333	4.000	4.667	5.333
	I y-y	0.001	0.002	0.005	0.010	0.018	0.028	0.042	0.059	0.081	0.141	0.223	0.333
4 1/8	Wt.	0.624	0.936	1.248	1.560	1.872	2.184	2.496	2.808	3.120	3.743	4.367	4.991
	Area	0.516	0.773	1.031	1.289	1.547	1.805	2.063	2.320	2.578	3.094	3.609	4.125
	I x-x	0.731	1.097	1.462	1.828	2.193	2.559	2.925	3.290	3.656	4.387	5.118	5.849
	I y-y	0.001	0.002	0.005	0.010	0.018	0.029	0.043	0.061	0.084	0.145	0.230	0.344
4 1/4	Wt.	0.643	0.964	1.286	1.607	1.928	2.250	2.571	2.893	3.214	3.857	4.500	5.143
	Area	0.531	0.797	1.063	1.328	1.594	1.859	2.125	2.391	2.656	3.188	3.719	4.250
	I x-x	0.800	1.200	1.599	1.999	2.399	2.799	3.199	3.598	3.998	4.798	5.598	6.397
	I y-y	0.001	0.002	0.006	0.011	0.019	0.030	0.044	0.063	0.086	0.149	0.237	0.354
4 3/8	Wt.	0.662	0.993	1.323	1.654	1.985	2.316	2.647	2.978	3.309	3.970	4.632	5.294
	Area	0.547	0.820	1.094	1.367	1.641	1.914	2.188	2.461	2.734	3.281	3.828	4.375
	I x-x	0.872	1.308	1.745	2.181	2.617	3.053	3.489	3.925	4.362	5.234	6.106	6.978
	I y-y	0.001	0.002	0.006	0.011	0.019	0.031	0.046	0.065	0.089	0.154	0.244	0.365
4 1/2	Wt.	0.681	1.021	1.361	1.702	2.042	2.382	2.723	3.063	3.403	4.084	4.764	5.445
	Area	0.563	0.844	1.125	1.406	1.688	1.969	2.250	2.531	2.813	3.375	3.938	4.500
	I x-x	0.949	1.424	1.898	2.373	2.848	3.322	3.797	4.272	4.746	5.695	6.645	7.594
	I y-y	0.001	0.002	0.006	0.011	0.020	0.031	0.047	0.067	0.092	0.158	0.251	0.375
4 5/8	Wt.	0.700	1.049	1.399	1.749	2.099	2.448	2.798	3.148	3.498	4.197	4.897	5.596
	Area	0.578	0.867	1.156	1.445	1.734	2.023	2.313	2.602	2.891	3.469	4.047	4.625
	I x-x	1.031	1.546	2.061	2.576	3.092	3.607	4.122	4.637	5.153	6.183	7.214	8.244
	I y-y	0.001	0.003	0.006	0.012	0.020	0.032	0.048	0.069	0.094	0.163	0.258	0.385
4 3/4	Wt.	0.718	1.078	1.437	1.796	2.155	2.515	2.874	3.233	3.592	4.311	5.029	5.748
	Area	0.594	0.891	1.188	1.484	1.781	2.078	2.375	2.672	2.969	3.563	4.156	4.750
	I x-x	1.116	1.675	2.233	2.791	3.349	3.907	4.466	5.024	5.582	6.698	7.815	8.931
	I y-y	0.001	0.003	0.006	0.012	0.021	0.033	0.049	0.070	0.097	0.167	0.265	0.396
4 7/8	Wt.	0.737	1.106	1.475	1.843	2.212	2.581	2.949	3.318	3.687	4.424	5.162	5.899
	Area	0.609	0.914	1.219	1.523	1.828	2.133	2.438	2.742	3.047	3.656	4.266	4.875
	I x-x	1.207	1.810	2.414	3.017	3.621	4.224	4.827	5.431	6.034	7.241	8.448	9.655
	I y-y	0.001	0.003	0.006	0.012	0.021	0.034	0.051	0.072	0.099	0.171	0.272	0.406



RECTANGLES

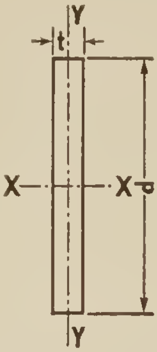
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		⅛	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1
5	Wt.	0.756	1.134	1.513	1.891	2.269	2.647	3.025	3.403	3.781	4.538	5.294	6.050
	Area	0.625	0.938	1.250	1.563	1.875	2.188	2.500	2.813	3.125	3.750	4.375	5.000
	I x-x	1.302	1.953	2.604	3.255	3.906	4.557	5.208	5.859	6.510	7.813	9.115	10.42
	I y-y	0.001	0.003	0.007	0.013	0.022	0.035	0.052	0.074	0.102	0.176	0.279	0.417
5⅛	Wt.	0.775	1.163	1.550	1.938	2.325	2.713	3.101	3.488	3.876	4.651	5.426	6.201
	Area	0.641	0.961	1.281	1.602	1.922	2.242	2.563	2.883	3.203	3.844	4.484	5.125
	I x-x	1.402	2.103	2.804	3.506	4.207	4.908	5.609	6.310	7.011	8.413	9.815	11.22
	I y-y	0.001	0.003	0.007	0.013	0.023	0.036	0.053	0.076	0.104	0.180	0.286	0.427
5¼	Wt.	0.794	1.191	1.588	1.985	2.382	2.779	3.176	3.573	3.970	4.764	5.558	6.353
	Area	0.656	0.984	1.313	1.641	1.969	2.297	2.625	2.953	3.281	3.938	4.594	5.250
	I x-x	1.507	2.261	3.015	3.768	4.522	5.276	6.029	6.783	7.537	9.044	10.55	12.06
	I y-y	0.001	0.003	0.007	0.013	0.023	0.037	0.055	0.078	0.107	0.185	0.293	0.437
5⅜	Wt.	0.813	1.219	1.626	2.032	2.439	2.845	3.252	3.658	4.065	4.878	5.691	6.504
	Area	0.672	1.008	1.344	1.680	2.016	2.352	2.688	3.023	3.359	4.031	4.703	5.375
	I x-x	1.618	2.426	3.235	4.044	4.853	5.662	6.470	7.279	8.088	9.705	11.32	12.94
	I y-y	0.001	0.003	0.007	0.014	0.024	0.038	0.056	0.080	0.109	0.189	0.300	0.448
5½	Wt.	0.832	1.248	1.664	2.080	2.496	2.912	3.328	3.743	4.159	4.991	5.823	6.655
	Area	0.688	1.031	1.375	1.719	2.063	2.406	2.750	3.094	3.438	4.125	4.813	5.500
	I x-x	1.733	2.600	3.466	4.333	5.199	6.066	6.932	7.799	8.665	10.40	12.13	13.86
	I y-y	0.001	0.003	0.007	0.014	0.024	0.038	0.057	0.082	0.112	0.193	0.307	0.458
5⅝	Wt.	0.851	1.276	1.702	2.127	2.552	2.978	3.403	3.829	4.254	5.105	5.955	6.806
	Area	0.703	1.055	1.406	1.758	2.109	2.461	2.813	3.164	3.516	4.219	4.922	5.625
	I x-x	1.854	2.781	3.708	4.635	5.562	6.489	7.416	8.343	9.270	11.12	12.98	14.83
	I y-y	0.001	0.003	0.007	0.014	0.025	0.039	0.059	0.083	0.114	0.198	0.314	0.469
5¾	Wt.	0.870	1.305	1.739	2.174	2.609	3.044	3.479	3.914	4.348	5.218	6.088	6.958
	Area	0.719	1.078	1.438	1.797	2.156	2.516	2.875	3.234	3.594	4.313	5.031	5.750
	I x-x	1.980	2.971	3.961	4.951	5.941	6.931	7.921	8.911	9.902	11.88	13.86	15.84
	I y-y	0.001	0.003	0.007	0.015	0.025	0.040	0.060	0.085	0.117	0.202	0.321	0.479
5⅞	Wt.	0.889	1.333	1.777	2.222	2.666	3.110	3.554	3.999	4.443	5.332	6.220	7.109
	Area	0.734	1.102	1.469	1.836	2.203	2.570	2.938	3.305	3.672	4.406	5.141	5.875
	I x-x	2.112	3.168	4.225	5.281	6.337	7.393	8.449	9.505	10.56	12.67	14.79	16.90
	I y-y	0.001	0.003	0.008	0.015	0.026	0.041	0.061	0.087	0.120	0.207	0.328	0.490



RECTANGLES

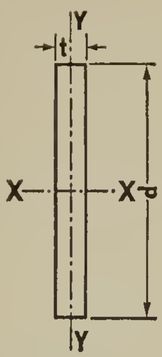
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x-x} = \frac{I_{x-x}}{d/2}$; $S_{y-y} = \frac{I_{y-y}}{t/2}$

Radius of Gyration: $r_{x-x} = 0.289\ d$; $r_{y-y} = 0.289\ t$

Depth, d		Thickness, t											
		⅛	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1
6	Wt.	0.908	1.361	1.815	2.269	2.723	3.176	3.630	4.084	4.538	5.445	6.353	7.260
	Area	0.750	1.125	1.500	1.875	2.250	2.625	3.000	3.375	3.750	4.500	5.250	6.000
	I x-x	2.250	3.375	4.500	5.625	6.750	7.875	9.000	10.13	11.25	13.50	15.75	18.00
	I y-y	0.001	0.003	0.008	0.015	0.026	0.042	0.063	0.089	0.122	0.211	0.335	0.500
6⅛	Wt.	0.926	1.390	1.853	2.316	2.779	3.242	3.706	4.169	4.632	5.558	6.485	7.411
	Area	0.766	1.148	1.531	1.914	2.297	2.680	3.063	3.445	3.828	4.594	5.359	6.125
	I x-x	2.394	3.590	4.787	5.984	7.181	8.378	9.574	10.77	11.97	14.36	16.76	19.15
	I y-y	0.001	0.003	0.008	0.016	0.027	0.043	0.064	0.091	0.125	0.215	0.342	0.510
6¼	Wt.	0.945	1.418	1.891	2.363	2.836	3.309	3.781	4.254	4.727	5.672	6.617	7.563
	Area	0.781	1.172	1.563	1.953	2.344	2.734	3.125	3.516	3.906	4.688	5.469	6.250
	I x-x	2.543	3.815	5.086	6.358	7.629	8.901	10.17	11.44	12.72	15.26	17.80	20.35
	I y-y	0.001	0.003	0.008	0.016	0.027	0.044	0.065	0.093	0.127	0.220	0.349	0.521
6⅜	Wt.	0.964	1.446	1.928	2.411	2.893	3.375	3.857	4.339	4.821	5.785	6.750	7.714
	Area	0.797	1.195	1.594	1.992	2.391	2.789	3.188	3.586	3.984	4.781	5.578	6.375
	I x-x	2.699	4.048	5.398	6.747	8.096	9.446	10.80	12.14	13.49	16.19	18.89	21.59
	I y-y	0.001	0.004	0.008	0.016	0.028	0.044	0.066	0.095	0.130	0.224	0.356	0.531
6½	Wt.	0.983	1.475	1.966	2.458	2.949	3.441	3.933	4.424	4.916	5.899	6.882	7.865
	Area	0.813	1.219	1.625	2.031	2.438	2.844	3.250	3.656	4.063	4.875	5.688	6.500
	I x-x	2.861	4.291	5.721	7.152	8.582	10.01	11.44	12.87	14.30	17.16	20.02	22.89
	I y-y	0.001	0.004	0.008	0.017	0.029	0.045	0.068	0.096	0.132	0.229	0.363	0.542
6⅝	Wt.	1.002	1.503	2.004	2.505	3.006	3.507	4.008	4.509	5.010	6.012	7.014	8.016
	Area	0.828	1.242	1.656	2.070	2.484	2.898	3.313	3.727	4.141	4.969	5.797	6.625
	I x-x	3.029	4.543	6.058	7.572	9.087	10.60	12.12	13.63	15.14	18.17	21.20	24.23
	I y-y	0.001	0.004	0.009	0.017	0.029	0.046	0.069	0.098	0.135	0.233	0.370	0.552
6¾	Wt.	1.021	1.531	2.042	2.552	3.063	3.573	4.084	4.594	5.105	6.126	7.147	8.168
	Area	0.844	1.266	1.688	2.109	2.531	2.953	3.375	3.797	4.219	5.063	5.906	6.750
	I x-x	3.204	4.805	6.407	8.009	9.611	11.21	12.81	14.42	16.02	19.22	22.43	25.63
	I y-y	0.001	0.004	0.009	0.017	0.030	0.047	0.070	0.100	0.137	0.237	0.377	0.562
6⅞	Wt.	1.040	1.560	2.080	2.600	3.120	3.639	4.159	4.679	5.199	6.239	7.279	8.319
	Area	0.859	1.289	1.719	2.148	2.578	3.008	3.438	3.867	4.297	5.156	6.016	6.875
	I x-x	3.385	5.077	6.770	8.462	10.15	11.85	13.54	15.23	16.92	20.31	23.69	27.08
	I y-y	0.001	0.004	0.009	0.017	0.030	0.048	0.072	0.102	0.140	0.242	0.384	0.573



RECTANGLES

ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
7	Wt.	1.059	1.588	2.118	2.647	3.176	3.706	4.235	4.764	5.294	6.353	7.411	8.470
	Area	0.875	1.313	1.750	2.188	2.625	3.063	3.500	3.938	4.375	5.250	6.125	7.000
	I x-x	3.573	5.359	7.146	8.932	10.72	12.51	14.29	16.08	17.86	21.44	25.01	28.58
	I y-y	0.001	0.004	0.009	0.018	0.031	0.049	0.073	0.104	0.142	0.246	0.391	0.583
7 1/8	Wt.	1.078	1.616	2.155	2.694	3.233	3.772	4.311	4.849	5.388	6.466	7.544	8.621
	Area	0.891	1.336	1.781	2.227	2.672	3.117	3.563	4.008	4.453	5.344	6.234	7.125
	I x-x	3.768	5.652	7.536	9.419	11.30	13.19	15.07	16.95	18.84	22.61	26.37	30.14
	I y-y	0.001	0.004	0.009	0.018	0.031	0.050	0.074	0.106	0.145	0.250	0.398	0.594
7 1/4	Wt.	1.097	1.645	2.193	2.741	3.290	3.838	4.386	4.935	5.483	6.579	7.676	8.773
	Area	0.906	1.359	1.813	2.266	2.719	3.172	3.625	4.078	4.531	5.438	6.344	7.250
	I x-x	3.970	5.954	7.939	9.924	11.91	13.89	15.88	17.86	19.85	23.82	27.79	31.76
	I y-y	0.001	0.004	0.009	0.018	0.032	0.051	0.076	0.108	0.148	0.255	0.405	0.604
7 3/8	Wt.	1.115	1.673	2.231	2.789	3.346	3.904	4.462	5.020	5.577	6.693	7.808	8.924
	Area	0.922	1.383	1.844	2.305	2.766	3.227	3.688	4.148	4.609	5.531	6.453	7.375
	I x-x	4.178	6.268	8.357	10.45	12.54	14.62	16.71	18.80	20.89	25.07	29.25	33.43
	I y-y	0.001	0.004	0.010	0.019	0.032	0.051	0.077	0.109	0.150	0.259	0.412	0.615
7 1/2	Wt.	1.134	1.702	2.269	2.836	3.403	3.970	4.538	5.105	5.672	6.806	7.941	9.075
	Area	0.938	1.406	1.875	2.344	2.813	3.281	3.750	4.219	4.688	5.625	6.563	7.500
	I x-x	4.395	6.592	8.789	10.99	13.18	15.38	17.58	19.78	21.97	26.37	30.76	35.16
	I y-y	0.001	0.004	0.010	0.019	0.033	0.052	0.078	0.111	0.153	0.264	0.419	0.625
7 5/8	Wt.	1.153	1.730	2.307	2.883	3.460	4.036	4.613	5.190	5.766	6.920	8.073	9.226
	Area	0.953	1.430	1.906	2.383	2.859	3.336	3.813	4.289	4.766	5.719	6.672	7.625
	I x-x	4.618	6.927	9.236	11.54	13.85	16.16	18.47	20.78	23.09	27.71	32.33	36.94
	I y-y	0.001	0.004	0.010	0.019	0.034	0.053	0.079	0.113	0.155	0.268	0.426	0.635
7 3/4	Wt.	1.172	1.758	2.344	2.930	3.517	4.103	4.689	5.275	5.861	7.033	8.205	9.378
	Area	0.969	1.453	1.938	2.422	2.906	3.391	3.875	4.359	4.844	5.813	6.781	7.750
	I x-x	4.849	7.273	9.698	12.12	14.55	16.97	19.40	21.82	24.24	29.09	33.94	38.79
	I y-y	0.001	0.004	0.010	0.020	0.034	0.054	0.081	0.115	0.158	0.272	0.433	0.646
7 7/8	Wt.	1.191	1.787	2.382	2.978	3.573	4.169	4.764	5.360	5.955	7.147	8.338	9.529
	Area	0.984	1.477	1.969	2.461	2.953	3.445	3.938	4.430	4.922	5.906	6.891	7.875
	I x-x	5.087	7.631	10.17	12.72	15.26	17.81	20.35	22.89	25.44	30.52	35.61	40.70
	I y-y	0.001	0.004	0.010	0.020	0.035	0.055	0.082	0.117	0.160	0.277	0.440	0.656

RECTANGLES

ELEMENTS OF SECTIONS

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Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
8	Wt.	1.210	1.815	2.420	3.025	3.630	4.235	4.840	5.445	6.050	7.260	8.470	9.680
	Area	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500	5.000	6.000	7.000	8.000
	I x-x	5.333	8.000	10.67	13.33	16.00	18.67	21.33	24.00	26.67	32.00	37.33	42.67
	I y-y	0.001	0.004	0.010	0.020	0.035	0.056	0.083	0.119	0.163	0.281	0.447	0.667
8 1/8	Wt.	1.229	1.843	2.458	3.072	3.687	4.301	4.916	5.530	6.145	7.373	8.602	9.831
	Area	1.016	1.523	2.031	2.539	3.047	3.555	4.063	4.570	5.078	6.094	7.109	8.125
	I x-x	5.587	8.381	11.17	13.97	16.76	19.56	22.35	25.14	27.94	33.52	39.11	44.70
	I y-y	0.001	0.004	0.011	0.021	0.036	0.057	0.085	0.121	0.165	0.286	0.454	0.677
8 1/4	Wt.	1.248	1.872	2.496	3.120	3.743	4.367	4.991	5.615	6.239	7.487	8.735	9.983
	Area	1.031	1.547	2.063	2.578	3.094	3.609	4.125	4.641	5.156	6.188	7.219	8.250
	I x-x	5.849	8.774	11.70	14.62	17.55	20.47	23.40	26.32	29.25	35.09	40.94	46.79
	I y-y	0.001	0.005	0.011	0.021	0.036	0.058	0.086	0.122	0.168	0.290	0.461	0.687
8 3/8	Wt.	1.267	1.900	2.533	3.167	3.800	4.434	5.067	5.700	6.334	7.600	8.867	10.13
	Area	1.047	1.570	2.094	2.617	3.141	3.664	4.188	4.711	5.234	6.281	7.328	8.375
	I x-x	6.119	9.179	12.24	15.30	18.36	21.42	24.48	27.54	30.60	36.71	42.83	48.95
	I y-y	0.001	0.005	0.011	0.021	0.037	0.058	0.087	0.124	0.170	0.294	0.468	0.698
8 1/2	Wt.	1.286	1.928	2.571	3.214	3.857	4.500	5.143	5.785	6.428	7.714	8.999	10.29
	Area	1.063	1.594	2.125	2.656	3.188	3.719	4.250	4.781	5.313	6.375	7.438	8.500
	I x-x	6.397	9.596	12.79	15.99	19.19	22.39	25.59	28.79	31.99	38.38	44.78	51.18
	I y-y	0.001	0.005	0.011	0.022	0.037	0.059	0.089	0.126	0.173	0.299	0.475	0.708
8 5/8	Wt.	1.305	1.957	2.609	3.261	3.914	4.566	5.218	5.870	6.523	7.827	9.132	10.44
	Area	1.078	1.617	2.156	2.695	3.234	3.773	4.313	4.852	5.391	6.469	7.547	8.625
	I x-x	6.684	10.03	13.37	16.71	20.05	23.39	26.73	30.08	33.42	40.10	46.78	53.47
	I y-y	0.001	0.005	0.011	0.022	0.038	0.060	0.090	0.128	0.175	0.303	0.482	0.719
8 3/4	Wt.	1.323	1.985	2.647	3.309	3.970	4.632	5.294	5.955	6.617	7.941	9.264	10.59
	Area	1.094	1.641	2.188	2.734	3.281	3.828	4.375	4.922	5.469	6.563	7.656	8.750
	I x-x	6.978	10.47	13.96	17.45	20.94	24.42	27.91	31.40	34.89	41.87	48.85	55.83
	I y-y	0.001	0.005	0.011	0.022	0.038	0.061	0.091	0.130	0.178	0.308	0.488	0.729
8 7/8	Wt.	1.342	2.014	2.685	3.356	4.027	4.698	5.369	6.041	6.712	8.054	9.396	10.74
	Area	1.109	1.664	2.219	2.773	3.328	3.883	4.438	4.992	5.547	6.656	7.766	8.875
	I x-x	7.282	10.92	14.56	18.20	21.85	25.49	29.13	32.77	36.41	43.69	50.97	58.25
	I y-y	0.001	0.005	0.012	0.023	0.039	0.062	0.092	0.132	0.181	0.312	0.495	0.740

RECTANGLES

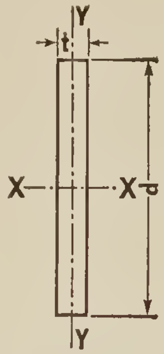
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x-x}=\frac{I_{x-x}}{d/2}$; $S_{y-y}=\frac{I_{y-y}}{t/2}$

Radius of Gyration: $r_{x-x}=0.289\ d$; $r_{y-y}=0.289\ t$

Depth, d		Thickness, t											
		⅛	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1
9	Wt.	1.361	2.042	2.723	3.403	4.084	4.764	5.445	6.126	6.806	8.168	9.529	10.89
	Area	1.125	1.688	2.250	2.813	3.375	3.938	4.500	5.063	5.625	6.750	7.875	9.000
	I x-x	7.594	11.39	15.19	18.98	22.78	26.58	30.38	34.17	37.97	45.56	53.16	60.75
	I y-y	0.001	0.005	0.012	0.023	0.040	0.063	0.094	0.133	0.183	0.316	0.502	0.750
9⅛	Wt.	1.380	2.070	2.760	3.450	4.140	4.831	5.521	6.211	6.901	8.281	9.661	11.04
	Area	1.141	1.711	2.281	2.852	3.422	3.992	4.563	5.133	5.703	6.844	7.984	9.125
	I x-x	7.915	11.87	15.83	19.79	23.74	27.70	31.66	35.62	39.57	47.49	55.40	63.32
	I y-y	0.001	0.005	0.012	0.023	0.040	0.064	0.095	0.135	0.186	0.321	0.509	0.760
9¼	Wt.	1.399	2.099	2.798	3.498	4.197	4.897	5.596	6.296	6.995	8.394	9.793	11.19
	Area	1.156	1.734	2.313	2.891	3.469	4.047	4.625	5.203	5.781	6.938	8.094	9.250
	I x-x	8.244	12.37	16.49	20.61	24.73	28.86	32.98	37.10	41.22	49.47	57.71	65.95
	I y-y	0.002	0.005	0.012	0.024	0.041	0.065	0.096	0.137	0.188	0.325	0.516	0.771
9⅜	Wt.	1.418	2.127	2.836	3.545	4.254	4.963	5.672	6.381	7.090	8.508	9.926	11.34
	Area	1.172	1.758	2.344	2.930	3.516	4.102	4.688	5.273	5.859	7.031	8.203	9.375
	I x-x	8.583	12.87	17.17	21.46	25.75	30.04	34.33	38.62	42.92	51.50	60.08	68.66
	I y-y	0.002	0.005	0.012	0.024	0.041	0.065	0.098	0.139	0.191	0.330	0.523	0.781
9½	Wt.	1.437	2.155	2.874	3.592	4.311	5.029	5.748	6.466	7.184	8.621	10.06	11.50
	Area	1.188	1.781	2.375	2.969	3.563	4.156	4.750	5.344	5.938	7.125	8.313	9.500
	I x-x	8.931	13.40	17.86	22.33	26.79	31.26	35.72	40.19	44.66	53.59	62.52	71.45
	I y-y	0.002	0.005	0.012	0.024	0.042	0.066	0.099	0.141	0.193	0.334	0.530	0.792
9⅝	Wt.	1.456	2.184	2.912	3.639	4.367	5.095	5.823	6.551	7.279	8.735	10.19	11.65
	Area	1.203	1.805	2.406	3.008	3.609	4.211	4.813	5.414	6.016	7.219	8.422	9.625
	I x-x	9.288	13.93	18.58	23.22	27.86	32.51	37.15	41.80	46.44	55.73	65.02	74.31
	I y-y	0.002	0.005	0.013	0.024	0.042	0.067	0.100	0.143	0.196	0.338	0.537	0.802
9¾	Wt.	1.475	2.212	2.949	3.687	4.424	5.161	5.899	6.636	7.373	8.848	10.32	11.80
	Area	1.219	1.828	2.438	3.047	3.656	4.266	4.875	5.484	6.094	7.313	8.531	9.750
	I x-x	9.655	14.48	19.31	24.14	28.96	33.79	38.62	43.45	48.27	57.93	67.58	77.24
	I y-y	0.002	0.005	0.013	0.025	0.043	0.068	0.102	0.145	0.198	0.343	0.544	0.812
9⅞	Wt.	1.494	2.240	2.987	3.734	4.481	5.228	5.974	6.721	7.468	8.962	10.46	11.95
	Area	1.234	1.852	2.469	3.086	3.703	4.320	4.938	5.555	6.172	7.406	8.641	9.875
	I x-x	10.03	15.05	20.06	25.08	30.09	35.11	40.12	45.14	50.15	60.19	70.22	80.25
	I y-y	0.002	0.005	0.013	0.025	0.043	0.069	0.103	0.146	0.201	0.347	0.551	0.823



RECTANGLES

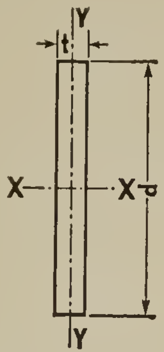
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I=Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x}=\dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289\, d$; $r_{y\text{-}y}=0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
10	Wt.	1.513	2.269	3.025	3.781	4.538	5.294	6.050	6.806	7.563	9.075	10.59	12.10
	Area	1.250	1.875	2.500	3.125	3.750	4.375	5.000	5.625	6.250	7.500	8.750	10.00
	I x-x	10.42	15.63	20.83	26.04	31.25	36.46	41.67	46.88	52.08	62.50	72.92	83.33
	I y-y	0.002	0.005	0.013	0.025	0.044	0.070	0.104	0.148	0.203	0.352	0.558	0.833
10 1/8	Wt.	1.531	2.297	3.063	3.829	4.594	5.360	6.126	6.891	7.657	9.188	10.72	12.25
	Area	1.266	1.898	2.531	3.164	3.797	4.430	5.063	5.695	6.328	7.594	8.859	10.13
	I x-x	10.81	16.22	21.62	27.03	32.44	37.84	43.25	48.65	54.06	64.87	75.69	86.50
	I y-y	0.002	0.006	0.013	0.026	0.044	0.071	0.105	0.150	0.206	0.356	0.565	0.844
10 1/4	Wt.	1.550	2.325	3.101	3.876	4.651	5.426	6.201	6.976	7.752	9.302	10.85	12.40
	Area	1.281	1.922	2.563	3.203	3.844	4.484	5.125	5.766	6.406	7.688	8.969	10.25
	I x-x	11.22	16.83	22.44	28.04	33.65	39.26	44.87	50.48	56.09	67.31	78.52	89.74
	I y-y	0.002	0.006	0.013	0.026	0.045	0.072	0.107	0.152	0.209	0.360	0.572	0.854
10 3/8	Wt.	1.569	2.354	3.138	3.923	4.708	5.492	6.277	7.061	7.846	9.415	10.98	12.55
	Area	1.297	1.945	2.594	3.242	3.891	4.539	5.188	5.836	6.484	7.781	9.078	10.38
	I x-x	11.63	17.45	23.27	29.08	34.90	40.72	46.53	52.35	58.17	69.80	81.43	93.06
	I y-y	0.002	0.006	0.014	0.026	0.046	0.072	0.108	0.154	0.211	0.365	0.579	0.865
10 1/2	Wt.	1.588	2.382	3.176	3.970	4.764	5.558	6.353	7.147	7.941	9.529	11.12	12.71
	Area	1.313	1.969	2.625	3.281	3.938	4.594	5.250	5.906	6.563	7.875	9.188	10.50
	I x-x	12.06	18.09	24.12	30.15	36.18	42.21	48.23	54.26	60.29	72.35	84.41	96.47
	I y-y	0.002	0.006	0.014	0.027	0.046	0.073	0.109	0.156	0.214	0.369	0.586	0.875
10 5/8	Wt.	1.607	2.411	3.214	4.018	4.821	5.625	6.428	7.232	8.035	9.642	11.25	12.86
	Area	1.328	1.992	2.656	3.320	3.984	4.648	5.313	5.977	6.641	7.969	9.297	10.63
	I x-x	12.49	18.74	24.99	31.24	37.48	43.73	49.98	56.22	62.47	74.97	87.46	99.95
	I y-y	0.002	0.006	0.014	0.027	0.047	0.074	0.111	0.158	0.216	0.374	0.593	0.885
10 3/4	Wt.	1.626	2.439	3.252	4.065	4.878	5.691	6.504	7.317	8.130	9.756	11.38	13.01
	Area	1.344	2.016	2.688	3.359	4.031	4.703	5.375	6.047	6.719	8.063	9.406	10.75
	I x-x	12.94	19.41	25.88	32.35	38.82	45.29	51.76	58.23	64.70	77.64	90.58	103.5
	I y-y	0.002	0.006	0.014	0.027	0.047	0.075	0.112	0.159	0.219	0.378	0.600	0.896
10 7/8	Wt.	1.645	2.467	3.290	4.112	4.935	5.757	6.579	7.402	8.224	9.869	11.51	13.16
	Area	1.359	2.039	2.719	3.398	4.078	4.758	5.438	6.117	6.797	8.156	9.516	10.88
	I x-x	13.40	20.10	26.79	33.49	40.19	46.89	53.59	60.29	66.99	80.38	93.78	107.2
	I y-y	0.002	0.006	0.014	0.028	0.048	0.076	0.113	0.161	0.221	0.382	0.607	0.906



RECTANGLES

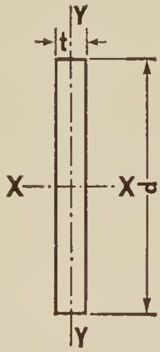
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		⅛	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1
11	Wt.	1.664	2.496	3.328	4.159	4.991	5.823	6.655	7.487	8.319	9.983	11.65	13.31
	Area	1.375	2.063	2.750	3.438	4.125	4.813	5.500	6.188	6.875	8.250	9.625	11.00
	I x-x	13.86	20.80	27.73	34.66	41.59	48.53	55.46	62.39	69.32	83.19	97.05	110.9
	I y-y	0.002	0.006	0.014	0.028	0.048	0.077	0.115	0.163	0.224	0.387	0.614	0.917
11⅛	Wt.	1.683	2.524	3.365	4.207	5.048	5.889	6.731	7.572	8.413	10.10	11.78	13.46
	Area	1.391	2.086	2.781	3.477	4.172	4.867	5.563	6.258	6.953	8.344	9.734	11.13
	I x-x	14.34	21.51	28.69	35.86	43.03	50.20	57.37	64.54	71.71	86.06	100.4	114.7
	I y-y	0.002	0.006	0.014	0.028	0.049	0.078	0.116	0.165	0.226	0.391	0.621	0.927
11¼	Wt.	1.702	2.552	3.403	4.254	5.105	5.955	6.806	7.657	8.508	10.21	11.91	13.61
	Area	1.406	2.109	2.813	3.516	4.219	4.922	5.625	6.328	7.031	8.438	9.844	11.25
	I x-x	14.83	22.25	29.66	37.08	44.49	51.91	59.33	66.74	74.16	88.99	103.8	118.7
	I y-y	0.002	0.006	0.015	0.029	0.049	0.079	0.117	0.167	0.229	0.396	0.628	0.937
11⅜	Wt.	1.720	2.581	3.441	4.301	5.161	6.022	6.882	7.742	8.602	10.32	12.04	13.76
	Area	1.422	2.133	2.844	3.555	4.266	4.977	5.688	6.398	7.109	8.531	9.953	11.38
	I x-x	15.33	23.00	30.66	38.33	45.99	53.66	61.33	68.99	76.66	91.99	107.3	122.7
	I y-y	0.002	0.006	0.015	0.029	0.050	0.079	0.118	0.169	0.231	0.400	0.635	0.948
11½	Wt.	1.739	2.609	3.479	4.348	5.218	6.088	6.958	7.827	8.697	10.44	12.18	13.92
	Area	1.438	2.156	2.875	3.594	4.313	5.031	5.750	6.469	7.188	8.625	10.06	11.50
	I x-x	15.84	23.76	31.69	39.61	47.53	55.45	63.37	71.29	79.21	95.06	110.9	126.7
	I y-y	0.002	0.006	0.015	0.029	0.051	0.080	0.120	0.171	0.234	0.404	0.642	0.958
11⅝	Wt.	1.758	2.637	3.517	4.396	5.275	6.154	7.033	7.912	8.791	10.55	12.31	14.07
	Area	1.453	2.180	2.906	3.633	4.359	5.086	5.813	6.539	7.266	8.719	10.17	11.63
	I x-x	16.36	24.55	32.73	40.91	49.09	57.28	65.46	73.64	81.82	98.19	114.6	130.9
	I y-y	0.002	0.006	0.015	0.030	0.051	0.081	0.121	0.172	0.237	0.409	0.649	0.969
11¾	Wt.	1.777	2.666	3.554	4.443	5.332	6.220	7.109	7.997	8.886	10.66	12.44	14.22
	Area	1.469	2.203	2.938	3.672	4.406	5.141	5.875	6.609	7.344	8.813	10.28	11.75
	I x-x	16.90	25.35	33.80	42.25	50.69	59.14	67.59	76.04	84.49	101.4	118.3	135.2
	I y-y	0.002	0.006	0.015	0.030	0.052	0.082	0.122	0.174	0.239	0.413	0.656	0.979
11⅞	Wt.	1.796	2.694	3.592	4.490	5.388	6.286	7.184	8.082	8.980	10.78	12.57	14.37
	Area	1.484	2.227	2.969	3.711	4.453	5.195	5.938	6.680	7.422	8.906	10.39	11.88
	I x-x	17.44	26.17	34.89	43.61	52.33	61.05	69.77	78.49	87.22	104.7	122.1	139.5
	I y-y	0.002	0.007	0.015	0.030	0.052	0.083	0.124	0.176	0.242	0.417	0.663	0.990



RECTANGLES

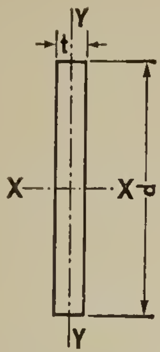
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		⅛	3⁄16	¼	5⁄16	⅜	7⁄16	½	9⁄16	⅝	¾	⅞	1
12	Wt.	1.815	2.723	3.630	4.538	5.445	6.353	7.260	8.168	9.075	10.89	12.71	14.52
	Area	1.500	2.250	3.000	3.750	4.500	5.250	6.000	6.750	7.500	9.000	10.50	12.00
	I x-x	18.00	27.00	36.00	45.00	54.00	63.00	72.00	81.00	90.00	108.0	126.0	144.0
	I y-y	0.002	0.007	0.016	0.031	0.053	0.084	0.125	0.178	0.244	0.422	0.670	1.000
12¼	Wt.	1.853	2.779	3.706	4.632	5.558	6.485	7.411	8.338	9.264	11.12	12.97	14.82
	Area	1.531	2.297	3.063	3.828	4.594	5.359	6.125	6.891	7.656	9.188	10.72	12.25
	I x-x	19.15	28.72	38.30	47.87	57.45	67.02	76.59	86.17	95.74	114.9	134.0	153.2
	I y-y	0.002	0.007	0.016	0.031	0.054	0.085	0.128	0.182	0.249	0.431	0.684	1.021
12½	Wt.	1.891	2.836	3.781	4.727	5.672	6.617	7.563	8.508	9.453	11.34	13.23	15.13
	Area	1.563	2.344	3.125	3.906	4.688	5.469	6.250	7.031	7.813	9.375	10.94	12.50
	I x-x	20.35	30.52	40.69	50.86	61.04	71.21	81.38	91.55	101.7	122.1	142.4	162.8
	I y-y	0.002	0.007	0.016	0.032	0.055	0.087	0.130	0.185	0.254	0.439	0.698	1.042
12¾	Wt.	1.928	2.893	3.857	4.821	5.785	6.750	7.714	8.678	9.642	11.57	13.50	15.43
	Area	1.594	2.391	3.188	3.984	4.781	5.578	6.375	7.172	7.969	9.563	11.16	12.75
	I x-x	21.59	32.39	43.18	53.98	64.77	75.57	86.36	97.16	108.0	129.5	151.1	172.7
	I y-y	0.002	0.007	0.017	0.032	0.056	0.089	0.133	0.189	0.259	0.448	0.712	1.062
13	Wt.	1.966	2.949	3.933	4.916	5.899	6.882	7.865	8.848	9.831	11.80	13.76	15.73
	Area	1.625	2.438	3.250	4.063	4.875	5.688	6.500	7.313	8.125	9.750	11.38	13.00
	I x-x	22.89	34.33	45.77	57.21	68.66	80.10	91.54	103.0	114.4	137.3	160.2	183.1
	I y-y	0.002	0.007	0.017	0.033	0.057	0.091	0.135	0.193	0.264	0.457	0.726	1.083
13¼	Wt.	2.004	3.006	4.008	5.010	6.012	7.014	8.016	9.018	10.02	12.02	14.03	16.03
	Area	1.656	2.484	3.313	4.141	4.969	5.797	6.625	7.453	8.281	9.938	11.59	13.25
	I x-x	24.23	36.35	48.46	60.58	72.69	84.81	96.93	109.0	121.2	145.4	169.6	193.9
	I y-y	0.002	0.007	0.017	0.034	0.058	0.092	0.138	0.197	0.270	0.466	0.740	1.104
13½	Wt.	2.042	3.063	4.084	5.105	6.126	7.147	8.168	9.188	10.21	12.25	14.29	16.34
	Area	1.688	2.531	3.375	4.219	5.063	5.906	6.750	7.594	8.438	10.13	11.81	13.50
	I x-x	25.63	38.44	51.26	64.07	76.89	89.70	102.5	115.3	128.1	153.8	179.4	205.0
	I y-y	0.002	0.007	0.018	0.034	0.059	0.094	0.141	0.200	0.275	0.475	0.754	1.125
13¾	Wt.	2.080	3.120	4.159	5.199	6.239	7.279	8.319	9.359	10.40	12.48	14.56	16.64
	Area	1.719	2.578	3.438	4.297	5.156	6.016	6.875	7.734	8.594	10.31	12.03	13.75
	I x-x	27.08	40.62	54.16	67.70	81.24	94.78	108.3	121.9	135.4	162.5	189.6	216.6
	I y-y	0.002	0.008	0.018	0.035	0.060	0.096	0.143	0.204	0.280	0.483	0.768	1.146



RECTANGLES

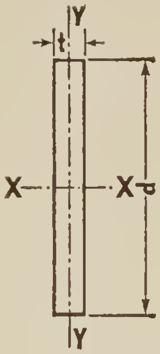
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		⅛	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1
14	Wt.	2.118	3.176	4.235	5.294	6.353	7.411	8.470	9.529	10.59	12.71	14.82	16.94
	Area	1.750	2.625	3.500	4.375	5.250	6.125	7.000	7.875	8.750	10.50	12.25	14.00
	I x-x	28.58	42.88	57.17	71.46	85.75	100.0	114.3	128.6	142.9	171.5	200.1	228.7
	I y-y	0.002	0.008	0.018	0.036	0.062	0.098	0.146	0.208	0.285	0.492	0.782	1.167
14¼	Wt.	2.155	3.233	4.311	5.388	6.466	7.544	8.621	9.699	10.78	12.93	15.09	17.24
	Area	1.781	2.672	3.563	4.453	5.344	6.234	7.125	8.016	8.906	10.69	12.47	14.25
	I x-x	30.14	45.21	60.28	75.36	90.43	105.5	120.6	135.6	150.7	180.9	211.0	241.1
	I y-y	0.002	0.008	0.019	0.036	0.063	0.099	0.148	0.211	0.290	0.501	0.796	1.187
14½	Wt.	2.193	3.290	4.386	5.483	6.579	7.676	8.773	9.869	10.97	13.16	15.35	17.55
	Area	1.813	2.719	3.625	4.531	5.438	6.344	7.250	8.156	9.063	10.88	12.69	14.50
	I x-x	31.76	47.63	63.51	79.39	95.27	111.1	127.0	142.9	158.8	190.5	222.3	254.1
	I y-y	0.002	0.008	0.019	0.037	0.064	0.101	0.151	0.215	0.295	0.510	0.809	1.208
14¾	Wt.	2.231	3.346	4.462	5.577	6.693	7.808	8.924	10.04	11.15	13.39	15.62	17.85
	Area	1.844	2.766	3.688	4.609	5.531	6.453	7.375	8.297	9.219	11.06	12.91	14.75
	I x-x	33.43	50.14	66.86	83.57	100.3	117.0	133.7	150.4	167.1	200.6	234.0	267.4
	I y-y	0.002	0.008	0.019	0.038	0.065	0.103	0.154	0.219	0.300	0.519	0.823	1.229
15	Wt.	2.269	3.403	4.538	5.672	6.806	7.941	9.075	10.21	11.34	13.61	15.88	18.15
	Area	1.875	2.813	3.750	4.688	5.625	6.563	7.500	8.438	9.375	11.25	13.13	15.00
	I x-x	35.16	52.73	70.31	87.89	105.5	123.0	140.6	158.2	175.8	210.9	246.1	281.3
	I y-y	0.002	0.008	0.020	0.038	0.066	0.105	0.156	0.222	0.305	0.527	0.837	1.250
15¼	Wt.	2.307	3.460	4.613	5.766	6.920	8.073	9.226	10.38	11.53	13.84	16.15	18.45
	Area	1.906	2.859	3.813	4.766	5.719	6.672	7.625	8.578	9.531	11.44	13.34	15.25
	I x-x	36.94	55.42	73.89	92.36	110.8	129.3	147.8	166.2	184.7	221.7	258.6	295.5
	I y-y	0.002	0.008	0.020	0.039	0.067	0.106	0.159	0.226	0.310	0.536	0.851	1.271
15½	Wt.	2.344	3.517	4.689	5.861	7.033	8.205	9.378	10.55	11.72	14.07	16.41	18.76
	Area	1.938	2.906	3.875	4.844	5.813	6.781	7.750	8.719	9.688	11.63	13.56	15.50
	I x-x	38.79	58.19	77.58	96.98	116.4	135.8	155.2	174.6	194.0	232.7	271.5	310.3
	I y-y	0.003	0.009	0.020	0.039	0.068	0.108	0.161	0.230	0.315	0.545	0.865	1.292
15¾	Wt.	2.382	3.573	4.764	5.955	7.147	8.338	9.529	10.72	11.91	14.29	16.68	19.06
	Area	1.969	2.953	3.938	4.922	5.906	6.891	7.875	8.859	9.844	11.81	13.78	15.75
	I x-x	40.70	61.05	81.40	101.7	122.1	142.4	162.8	183.1	203.5	244.2	284.9	325.6
	I y-y	0.003	0.009	0.021	0.040	0.069	0.110	0.164	0.234	0.320	0.554	0.879	1.312



RECTANGLES

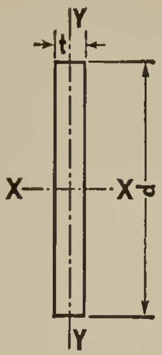
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^4

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		⅛	3⁄16	¼	5⁄16	⅜	7⁄16	½	9⁄16	⅝	¾	⅞	1
16	Wt.	2.420	3.630	4.840	6.050	7.260	8.470	9.680	10.89	12.10	14.52	16.94	19.36
	Area	2.000	3.000	4.000	5.000	6.000	7.000	8.000	9.000	10.00	12.00	14.00	16.00
	I x-x	42.67	64.00	85.33	106.7	128.0	149.3	170.7	192.0	213.3	256.0	298.7	341.3
	I y-y	0.003	0.009	0.021	0.041	0.070	0.112	0.167	0.237	0.326	0.562	0.893	1.333
16¼	Wt.	2.458	3.687	4.916	6.145	7.373	8.602	9.831	11.06	12.29	14.75	17.20	19.66
	Area	2.031	3.047	4.063	5.078	6.094	7.109	8.125	9.141	10.16	12.19	14.22	16.25
	I x-x	44.70	67.05	89.40	111.7	134.1	156.4	178.8	201.1	223.5	268.2	312.9	357.6
	I y-y	0.003	0.009	0.021	0.041	0.071	0.113	0.169	0.241	0.331	0.571	0.907	1.354
16½	Wt.	2.496	3.743	4.991	6.239	7.487	8.735	9.983	11.23	12.48	14.97	17.47	19.97
	Area	2.063	3.094	4.125	5.156	6.188	7.219	8.250	9.281	10.31	12.38	14.44	16.50
	I x-x	46.79	70.19	93.59	117.0	140.4	163.8	187.2	210.6	234.0	280.8	327.6	374.3
	I y-y	0.003	0.009	0.021	0.042	0.073	0.115	0.172	0.245	0.336	0.580	0.921	1.375
16¾	Wt.	2.533	3.800	5.067	6.334	7.600	8.867	10.13	11.40	12.67	15.20	17.73	20.27
	Area	2.094	3.141	4.188	5.234	6.281	7.328	8.375	9.422	10.47	12.56	14.66	16.75
	I x-x	48.95	73.43	97.90	122.4	146.9	171.3	195.8	220.3	244.8	293.7	342.7	391.6
	I y-y	0.003	0.009	0.022	0.043	0.074	0.117	0.174	0.248	0.341	0.589	0.935	1.396
17	Wt.	2.571	3.857	5.143	6.428	7.714	8.999	10.29	11.57	12.86	15.43	18.00	20.57
	Area	2.125	3.188	4.250	5.313	6.375	7.438	8.500	9.563	10.63	12.75	14.88	17.00
	I x-x	51.18	76.77	102.4	127.9	153.5	179.1	204.7	230.3	255.9	307.1	358.2	409.4
	I y-y	0.003	0.009	0.022	0.043	0.075	0.119	0.177	0.252	0.346	0.598	0.949	1.417
17¼	Wt.	2.609	3.914	5.218	6.523	7.827	9.132	10.44	11.74	13.05	15.65	18.26	20.87
	Area	2.156	3.234	4.313	5.391	6.469	7.547	8.625	9.703	10.78	12.94	15.09	17.25
	I x-x	53.47	80.20	106.9	133.7	160.4	187.1	213.9	240.6	267.3	320.8	374.3	427.7
	I y-y	0.003	0.009	0.022	0.044	0.076	0.120	0.180	0.256	0.351	0.606	0.963	1.437
17½	Wt.	2.647	3.970	5.294	6.617	7.941	9.264	10.59	11.91	13.23	15.88	18.53	21.18
	Area	2.188	3.281	4.375	5.469	6.563	7.656	8.750	9.844	10.94	13.13	15.31	17.50
	I x-x	55.83	83.74	111.7	139.6	167.5	195.4	223.3	251.2	279.1	335.0	390.8	446.6
	I y-y	0.003	0.010	0.023	0.045	0.077	0.122	0.182	0.260	0.356	0.615	0.977	1.458
17¾	Wt.	2.685	4.027	5.369	6.712	8.054	9.396	10.74	12.08	13.42	16.11	18.79	21.48
	Area	2.219	3.328	4.438	5.547	6.656	7.766	8.875	9.984	11.09	13.31	15.53	17.75
	I x-x	58.25	87.38	116.5	145.6	174.8	203.9	233.0	262.1	291.3	349.5	407.8	466.0
	I y-y	0.003	0.010	0.023	0.045	0.078	0.124	0.185	0.263	0.361	0.624	0.991	1.479



RECTANGLES

ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
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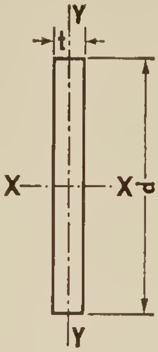
Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		⅛	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1
18	Wt.	2.723	4.084	5.445	6.806	8.168	9.529	10.89	12.25	13.61	16.34	19.06	21.78
	Area	2.250	3.375	4.500	5.625	6.750	7.875	9.000	10.13	11.25	13.50	15.75	18.00
	I x-x	60.75	91.13	121.5	151.9	182.3	212.6	243.0	273.4	303.8	364.5	425.3	486.0
	I y-y	0.003	0.010	0.023	0.046	0.079	0.126	0.188	0.267	0.366	0.633	1.005	1.500
18¼	Wt.	2.760	4.140	5.521	6.901	8.281	9.661	11.04	12.42	13.80	16.56	19.32	22.08
	Area	2.281	3.422	4.563	5.703	6.844	7.984	9.125	10.27	11.41	13.69	15.97	18.25
	I x-x	63.32	94.97	126.6	158.3	189.9	221.6	253.3	284.9	316.6	379.9	443.2	506.5
	I y-y	0.003	0.010	0.024	0.046	0.080	0.127	0.190	0.271	0.371	0.642	1.019	1.521
18½	Wt.	2.798	4.197	5.596	6.995	8.394	9.793	11.19	12.59	13.99	16.79	19.59	22.39
	Area	2.313	3.469	4.625	5.781	6.938	8.094	9.250	10.41	11.56	13.88	16.19	18.50
	I x-x	65.95	98.93	131.9	164.9	197.9	230.8	263.8	296.8	329.8	395.7	461.7	527.6
	I y-y	0.003	0.010	0.024	0.047	0.081	0.129	0.193	0.274	0.376	0.650	1.033	1.542
18¾	Wt.	2.836	4.254	5.672	7.090	8.508	9.926	11.34	12.76	14.18	17.02	19.85	22.69
	Area	2.344	3.516	4.688	5.859	7.031	8.203	9.375	10.55	11.72	14.06	16.41	18.75
	I x-x	68.66	103.0	137.3	171.7	206.0	240.3	274.7	309.0	343.3	412.0	480.7	549.3
	I y-y	0.003	0.010	0.024	0.048	0.082	0.131	0.195	0.278	0.381	0.659	1.047	1.562
19	Wt.	2.874	4.311	5.748	7.184	8.621	10.06	11.50	12.93	14.37	17.24	20.12	22.99
	Area	2.375	3.563	4.750	5.938	7.125	8.313	9.500	10.69	11.88	14.25	16.63	19.00
	I x-x	71.45	107.2	142.9	178.6	214.3	250.1	285.8	321.5	357.2	428.7	500.1	571.6
	I y-y	0.003	0.010	0.025	0.048	0.083	0.133	0.198	0.282	0.387	0.668	1.061	1.583
19¼	Wt.	2.912	4.367	5.823	7.279	8.735	10.19	11.65	13.10	14.56	17.47	20.38	23.29
	Area	2.406	3.609	4.813	6.016	7.219	8.422	9.625	10.83	12.03	14.44	16.84	19.25
	I x-x	74.31	111.5	148.6	185.8	222.9	260.1	297.2	334.4	371.5	445.8	520.1	594.4
	I y-y	0.003	0.011	0.025	0.049	0.085	0.134	0.201	0.286	0.392	0.677	1.075	1.604
19½	Wt.	2.949	4.424	5.899	7.373	8.848	10.32	11.80	13.27	14.75	17.70	20.65	23.60
	Area	2.438	3.656	4.875	6.094	7.313	8.531	9.750	10.97	12.19	14.63	17.06	19.50
	I x-x	77.24	115.9	154.5	193.1	231.7	270.3	309.0	347.6	386.2	463.4	540.7	617.9
	I y-y	0.003	0.011	0.025	0.050	0.086	0.136	0.203	0.289	0.397	0.686	1.089	1.625
19¾	Wt.	2.987	4.481	5.974	7.468	8.962	10.46	11.95	13.44	14.94	17.92	20.91	23.90
	Area	2.469	3.703	4.938	6.172	7.406	8.641	9.875	11.11	12.34	14.81	17.28	19.75
	I x-x	80.25	120.4	160.5	200.6	240.7	280.9	321.0	361.1	401.2	481.5	561.7	642.0
	I y-y	0.003	0.011	0.026	0.050	0.087	0.138	0.206	0.293	0.402	0.694	1.103	1.646



RECTANGLES

ELEMENTS OF SECTIONS

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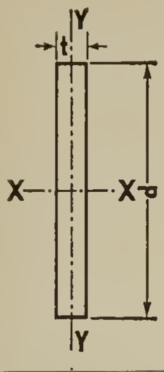
Depth, d		Thickness, t											
		⅛	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1
20	Wt.	3.025	4.538	6.050	7.563	9.075	10.59	12.10	13.61	15.13	18.15	21.18	24.20
	Area	2.500	3.750	5.000	6.250	7.500	8.750	10.00	11.25	12.50	15.00	17.50	20.00
	I x-x	83.33	125.0	166.7	208.3	250.0	291.7	333.3	375.0	416.7	500.0	583.3	666.7
	I y-y	0.003	0.011	0.026	0.051	0.088	0.140	0.208	0.297	0.407	0.703	1.117	1.667
20¼	Wt.	3.063	4.594	6.126	7.657	9.188	10.72	12.25	13.78	15.31	18.38	21.44	24.50
	Area	2.531	3.797	5.063	6.328	7.594	8.859	10.13	11.39	12.66	15.19	17.72	20.25
	I x-x	86.50	129.7	173.0	216.2	259.5	302.7	346.0	389.2	432.5	519.0	605.5	692.0
	I y-y	0.003	0.011	0.026	0.051	0.089	0.141	0.211	0.300	0.412	0.712	1.130	1.687
20½	Wt.	3.101	4.651	6.201	7.752	9.302	10.85	12.40	13.95	15.50	18.60	21.71	24.81
	Area	2.563	3.844	5.125	6.406	7.688	8.969	10.25	11.53	12.81	15.38	17.94	20.50
	I x-x	89.74	134.6	179.5	224.4	269.2	314.1	359.0	403.8	448.7	538.4	628.2	717.9
	I y-y	0.003	0.011	0.027	0.052	0.090	0.143	0.214	0.304	0.417	0.721	1.144	1.708
20¾	Wt.	3.138	4.708	6.277	7.846	9.415	10.98	12.55	14.12	15.69	18.83	21.97	25.11
	Area	2.594	3.891	5.188	6.484	7.781	9.078	10.38	11.67	12.97	15.56	18.16	20.75
	I x-x	93.06	139.6	186.1	232.7	279.2	325.7	372.3	418.8	465.3	558.4	651.5	744.5
	I y-y	0.003	0.011	0.027	0.053	0.091	0.145	0.216	0.308	0.422	0.729	1.158	1.729
21	Wt.	3.176	4.764	6.353	7.941	9.529	11.12	12.71	14.29	15.88	19.06	22.23	25.41
	Area	2.625	3.938	5.250	6.563	7.875	9.188	10.50	11.81	13.13	15.75	18.38	21.00
	I x-x	96.47	144.7	192.9	241.2	289.4	337.6	385.9	434.1	482.3	578.8	675.3	771.8
	I y-y	0.003	0.012	0.027	0.053	0.092	0.147	0.219	0.311	0.427	0.738	1.172	1.750
21¼	Wt.	3.214	4.821	6.428	8.035	9.642	11.25	12.86	14.46	16.07	19.28	22.50	25.71
	Area	2.656	3.984	5.313	6.641	7.969	9.297	10.63	11.95	13.28	15.94	18.59	21.25
	I x-x	99.96	149.9	199.9	249.9	299.9	349.8	399.8	449.8	499.8	599.7	699.7	799.6
	I y-y	0.003	0.012	0.028	0.054	0.093	0.148	0.221	0.315	0.432	0.747	1.186	1.771
21½	Wt.	3.252	4.878	6.504	8.130	9.756	11.38	13.01	14.63	16.26	19.51	22.76	26.02
	Area	2.688	4.031	5.375	6.719	8.063	9.406	10.75	12.09	13.44	16.13	18.81	21.50
	I x-x	103.5	155.3	207.1	258.8	310.6	362.3	414.1	465.9	517.6	621.1	724.7	828.2
	I y-y	0.003	0.012	0.028	0.055	0.094	0.150	0.224	0.319	0.437	0.756	1.200	1.792
21¾	Wt.	3.290	4.935	6.579	8.224	9.869	11.51	13.16	14.80	16.45	19.74	23.03	26.32
	Area	2.719	4.078	5.438	6.797	8.156	9.516	10.88	12.23	13.59	16.31	19.03	21.75
	I x-x	107.2	160.8	214.4	267.9	321.5	375.1	428.7	482.3	535.9	643.1	750.2	857.4
	I y-y	0.004	0.012	0.028	0.055	0.096	0.152	0.227	0.323	0.443	0.765	1.214	1.812



RECTANGLES

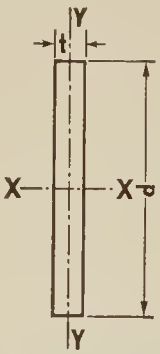
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in $in.^4$

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
22	Wt.	3.328	4.991	6.655	8.319	9.983	11.65	13.31	14.97	16.64	19.97	23.29	26.62
	Area	2.750	4.125	5.500	6.875	8.250	9.625	11.00	12.38	13.75	16.50	19.25	22.00
	I x-x	110.9	166.4	221.8	277.3	332.8	388.2	443.7	499.1	554.6	665.5	776.4	887.3
	I y-y	0.004	0.012	0.029	0.056	0.097	0.154	0.229	0.326	0.448	0.773	1.228	1.833
22¼	Wt.	3.365	5.048	6.731	8.413	10.10	11.78	13.46	15.14	16.83	20.19	23.56	26.92
	Area	2.781	4.172	5.563	6.953	8.344	9.734	11.13	12.52	13.91	16.69	19.47	22.25
	I x-x	114.7	172.1	229.5	286.8	344.2	401.6	459.0	516.3	573.7	688.4	803.2	917.9
	I y-y	0.004	0.012	0.029	0.057	0.098	0.155	0.232	0.330	0.453	0.782	1.242	1.854
22½	Wt.	3.403	5.105	6.806	8.508	10.21	11.91	13.61	15.31	17.02	20.42	23.82	27.23
	Area	2.813	4.219	5.625	7.031	8.438	9.844	11.25	12.66	14.06	16.88	19.69	22.50
	I x-x	118.7	178.0	237.3	296.6	356.0	415.3	474.6	534.0	593.3	711.9	830.6	949.3
	I y-y	0.004	0.012	0.029	0.057	0.099	0.157	0.234	0.334	0.458	0.791	1.256	1.875
22¾	Wt.	3.441	5.161	6.882	8.602	10.32	12.04	13.76	15.48	17.20	20.65	24.09	27.53
	Area	2.844	4.266	5.688	7.109	8.531	9.953	11.38	12.80	14.22	17.06	19.91	22.75
	I x-x	122.7	184.0	245.3	306.6	368.0	429.3	490.6	552.0	613.3	735.9	858.6	981.3
	I y-y	0.004	0.012	0.030	0.058	0.100	0.159	0.237	0.337	0.463	0.800	1.270	1.896
23	Wt.	3.479	5.218	6.958	8.697	10.44	12.18	13.92	15.65	17.39	20.87	24.35	27.83
	Area	2.875	4.313	5.750	7.188	8.625	10.06	11.50	12.94	14.38	17.25	20.13	23.00
	I x-x	126.7	190.1	253.5	316.8	380.2	443.6	507.0	570.3	633.7	760.4	887.2	1014.
	I y-y	0.004	0.013	0.030	0.058	0.101	0.161	0.240	0.341	0.468	0.809	1.284	1.917
23¼	Wt.	3.517	5.275	7.033	8.791	10.55	12.31	14.07	15.82	17.58	21.10	24.62	28.13
	Area	2.906	4.359	5.813	7.266	8.719	10.17	11.63	13.08	14.53	17.44	20.34	23.25
	I x-x	130.9	196.4	261.8	327.3	392.8	458.2	523.7	589.1	654.6	785.5	916.4	1047.
	I y-y	0.004	0.013	0.030	0.059	0.102	0.162	0.242	0.345	0.473	0.817	1.298	1.937
23½	Wt.	3.554	5.332	7.109	8.886	10.66	12.44	14.22	15.99	17.77	21.33	24.88	28.44
	Area	2.938	4.406	5.875	7.344	8.813	10.28	11.75	13.22	14.69	17.63	20.56	23.50
	I x-x	135.2	202.8	270.4	338.0	405.6	473.2	540.8	608.3	675.9	811.1	946.3	1082.
	I y-y	0.004	0.013	0.031	0.060	0.103	0.164	0.245	0.349	0.478	0.826	1.312	1.958
23¾	Wt.	3.592	5.388	7.184	8.980	10.78	12.57	14.37	16.16	17.96	21.55	25.15	28.74
	Area	2.969	4.453	5.938	7.422	8.906	10.39	11.88	13.36	14.84	17.81	20.78	23.75
	I x-x	139.5	209.3	279.1	348.9	418.6	488.4	558.2	627.9	697.7	837.3	976.8	1116.
	I y-y	0.004	0.013	0.031	0.060	0.104	0.166	0.247	0.352	0.483	0.835	1.326	1.979



RECTANGLES

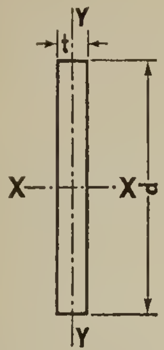
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
24	Wt.	3.630	5.445	7.260	9.075	10.89	12.71	14.52	16.34	18.15	21.78	25.41	29.04
	Area	3.000	4.500	6.000	7.500	9.000	10.50	12.00	13.50	15.00	18.00	21.00	24.00
	I x-x	144.0	216.0	288.0	360.0	432.0	504.0	576.0	648.0	720.0	864.0	1008.	1152.
	I y-y	0.004	0.013	0.031	0.061	0.105	0.167	0.250	0.356	0.488	0.844	1.340	2.000
24½	Wt.	3.706	5.558	7.411	9.264	11.12	12.97	14.82	16.68	18.53	22.23	25.94	29.65
	Area	3.063	4.594	6.125	7.656	9.188	10.72	12.25	13.78	15.31	18.38	21.44	24.50
	I x-x	153.2	229.8	306.4	383.0	459.6	536.2	612.8	689.3	765.9	919.1	1072.	1226.
	I y-y	0.004	0.013	0.032	0.062	0.108	0.171	0.255	0.363	0.498	0.861	1.368	2.042
25	Wt.	3.781	5.672	7.563	9.453	11.34	13.23	15.13	17.02	18.91	22.69	26.47	30.25
	Area	3.125	4.688	6.250	7.813	9.375	10.94	12.50	14.06	15.63	18.75	21.88	25.00
	I x-x	162.8	244.1	325.5	406.9	488.3	569.7	651.0	732.4	813.8	976.6	1139.	1302.
	I y-y	0.004	0.014	0.033	0.064	0.110	0.174	0.260	0.371	0.509	0.879	1.396	2.083
25½	Wt.	3.857	5.785	7.714	9.642	11.57	13.50	15.43	17.36	19.28	23.14	27.00	30.86
	Area	3.188	4.781	6.375	7.969	9.563	11.16	12.75	14.34	15.94	19.13	22.31	25.50
	I x-x	172.7	259.1	345.4	431.8	518.2	604.5	690.9	777.2	863.6	1036.	1209.	1382.
	I y-y	0.004	0.014	0.033	0.065	0.112	0.178	0.266	0.378	0.519	0.896	1.424	2.125
26	Wt.	3.933	5.899	7.865	9.831	11.80	13.76	15.73	17.70	19.66	23.60	27.53	31.46
	Area	3.250	4.875	6.500	8.125	9.750	11.38	13.00	14.63	16.25	19.50	22.75	26.00
	I x-x	183.1	274.6	366.2	457.7	549.3	640.8	732.3	823.9	915.4	1099.	1282.	1465.
	I y-y	0.004	0.014	0.034	0.066	0.114	0.181	0.271	0.386	0.529	0.914	1.452	2.167
26½	Wt.	4.008	6.012	8.016	10.02	12.02	14.03	16.03	18.04	20.04	24.05	28.06	32.07
	Area	3.313	4.969	6.625	8.281	9.938	11.59	13.25	14.91	16.56	19.88	23.19	26.50
	I x-x	193.9	290.8	387.7	484.6	581.6	678.5	775.4	872.3	969.3	1163.	1357.	1551.
	I y-y	0.004	0.015	0.035	0.067	0.116	0.185	0.276	0.393	0.539	0.932	1.479	2.208
27	Wt.	4.084	6.126	8.168	10.21	12.25	14.29	16.34	18.38	20.42	24.50	28.59	32.67
	Area	3.375	5.063	6.750	8.438	10.13	11.81	13.50	15.19	16.88	20.25	23.63	27.00
	I x-x	205.0	307.5	410.1	512.6	615.1	717.6	820.1	922.6	1025.	1230.	1435.	1640.
	I y-y	0.004	0.015	0.035	0.069	0.119	0.188	0.281	0.400	0.549	0.949	1.507	2.250
27½	Wt.	4.159	6.239	8.319	10.40	12.48	14.56	16.64	18.72	20.80	24.96	29.12	33.28
	Area	3.438	5.156	6.875	8.594	10.31	12.03	13.75	15.47	17.19	20.63	24.06	27.50
	I x-x	216.6	325.0	433.3	541.6	649.9	758.2	866.5	974.9	1083.	1300.	1516.	1733.
	I y-y	0.004	0.015	0.036	0.070	0.121	0.192	0.286	0.408	0.559	0.967	1.535	2.292



RECTANGLES

ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
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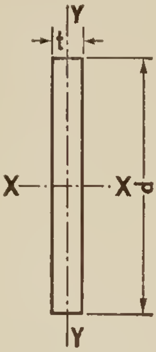
Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
28	Wt.	4.235	6.353	8.470	10.59	12.71	14.82	16.94	19.06	21.18	25.41	29.65	33.88
	Area	3.500	5.250	7.000	8.750	10.50	12.25	14.00	15.75	17.50	21.00	24.50	28.00
	I x-x	228.7	343.0	457.3	571.7	686.0	800.3	914.7	1029.	1143.	1372.	1601.	1829.
	I y-y	0.005	0.015	0.036	0.071	0.123	0.195	0.292	0.415	0.570	0.984	1.563	2.333
28½	Wt.	4.311	6.466	8.621	10.78	12.93	15.09	17.24	19.40	21.55	25.86	30.17	34.49
	Area	3.563	5.344	7.125	8.906	10.69	12.47	14.25	16.03	17.81	21.38	24.94	28.50
	I x-x	241.1	361.7	482.3	602.8	723.4	844.0	964.5	1085.	1206.	1447.	1688.	1929.
	I y-y	0.005	0.016	0.037	0.072	0.125	0.199	0.297	0.423	0.580	1.002	1.591	2.375
29	Wt.	4.386	6.579	8.773	10.97	13.16	15.35	17.55	19.74	21.93	26.32	30.70	35.09
	Area	3.625	5.438	7.250	9.063	10.88	12.69	14.50	16.31	18.13	21.75	25.38	29.00
	I x-x	254.1	381.1	508.1	635.1	762.2	889.2	1016.	1143.	1270.	1524.	1778.	2032.
	I y-y	0.005	0.016	0.038	0.074	0.127	0.202	0.302	0.430	0.590	1.020	1.619	2.417
29½	Wt.	4.462	6.693	8.924	11.15	13.39	15.62	17.85	20.08	22.31	26.77	31.23	35.70
	Area	3.688	5.531	7.375	9.219	11.06	12.91	14.75	16.59	18.44	22.13	25.81	29.50
	I x-x	267.4	401.1	534.8	668.5	802.3	936.0	1070.	1203.	1337.	1605.	1872.	2139.
	I y-y	0.005	0.016	0.038	0.075	0.130	0.206	0.307	0.438	0.600	1.037	1.647	2.458
30	Wt.	4.538	6.806	9.075	11.34	13.61	15.88	18.15	20.42	22.69	27.23	31.76	36.30
	Area	3.750	5.625	7.500	9.375	11.25	13.13	15.00	16.88	18.75	22.50	26.25	30.00
	I x-x	281.3	421.9	562.5	703.1	843.8	984.4	1125.	1266.	1406.	1688.	1969.	2250.
	I y-y	0.005	0.016	0.039	0.076	0.132	0.209	0.313	0.445	0.610	1.055	1.675	2.500
30½	Wt.	4.613	6.920	9.226	11.53	13.84	16.15	18.45	20.76	23.07	27.68	32.29	36.91
	Area	3.813	5.719	7.625	9.531	11.44	13.34	15.25	17.16	19.06	22.88	26.69	30.50
	I x-x	295.6	443.3	591.1	738.9	886.7	1034.	1182.	1330.	1478.	1773.	2069.	2364.
	I y-y	0.005	0.017	0.040	0.078	0.134	0.213	0.318	0.452	0.621	1.072	1.703	2.542
31	Wt.	4.689	7.033	9.378	11.72	14.07	16.41	18.76	21.10	23.44	28.13	32.82	37.51
	Area	3.875	5.813	7.750	9.688	11.63	13.56	15.50	17.44	19.38	23.25	27.13	31.00
	I x-x	310.3	465.5	620.6	775.8	931.0	1086.	1241.	1396.	1552.	1862.	2172.	2483.
	I y-y	0.005	0.017	0.040	0.079	0.136	0.216	0.323	0.460	0.631	1.090	1.731	2.583
31½	Wt.	4.764	7.147	9.529	11.91	14.29	16.68	19.06	21.44	23.82	28.59	33.35	38.12
	Area	3.938	5.906	7.875	9.844	11.81	13.78	15.75	17.72	19.69	23.63	27.56	31.50
	I x-x	325.6	488.4	651.2	814.0	976.8	1140.	1302.	1465.	1628.	1954.	2279.	2605.
	I y-y	0.005	0.017	0.041	0.080	0.138	0.220	0.328	0.467	0.641	1.107	1.759	2.625



RECTANGLES

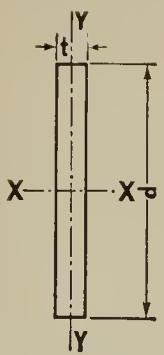
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		⅛	3⁄16	¼	5⁄16	⅜	7⁄16	½	9⁄16	⅝	¾	⅞	1
32	Wt.	4.840	7.260	9.680	12.10	14.52	16.94	19.36	21.78	24.20	29.04	33.88	38.72
	Area	4.000	6.000	8.000	10.00	12.00	14.00	16.00	18.00	20.00	24.00	28.00	32.00
	I x-x	341.3	512.0	682.7	853.3	1024.	1195.	1365.	1536.	1707.	2048.	2389.	2731.
	I y-y	0.005	0.018	0.042	0.081	0.141	0.223	0.333	0.475	0.651	1.125	1.786	2.667
32½	Wt.	4.916	7.373	9.831	12.29	14.75	17.20	19.66	22.12	24.58	29.49	34.41	39.33
	Area	4.063	6.094	8.125	10.16	12.19	14.22	16.25	18.28	20.31	24.38	28.44	32.50
	I x-x	357.6	536.4	715.2	894.0	1073.	1252.	1430	1609.	1788.	2146.	2503.	2861.
	I y-y	0.005	0.018	0.042	0.083	0.143	0.227	0.339	0.482	0.661	1.143	1.814	2.708
33	Wt.	4.991	7.487	9.983	12.48	14.97	17.47	19.97	22.46	24.96	29.95	34.94	39.93
	Area	4.125	6.188	8.250	10.31	12.38	14.44	16.50	18.56	20.63	24.75	28.88	33.00
	I x-x	374.3	561.5	748.7	935.9	1123.	1310.	1497.	1685.	1872.	2246.	2620.	2995.
	I y-y	0.005	0.018	0.043	0.084	0.145	0.230	0.344	0.489	0.671	1.160	1.842	2.750
33½	Wt.	5.067	7.600	10.13	12.67	15.20	17.73	20.27	22.80	25.33	30.40	35.47	40.54
	Area	4.188	6.281	8.375	10.47	12.56	14.66	16.75	18.84	20.94	25.13	29.31	33.50
	I x-x	391.6	587.4	783.2	979.0	1175.	1371.	1566.	1762.	1958.	2350.	2741.	3133.
	I y-y	0.005	0.018	0.044	0.085	0.147	0.234	0.349	0.497	0.682	1.178	1.870	2.792
34	Wt.	5.143	7.714	10.29	12.86	15.43	18.00	20.57	23.14	25.71	30.86	36.00	41.14
	Area	4.250	6.375	8.500	10.63	12.75	14.88	17.00	19.13	21.25	25.50	29.75	34.00
	I x-x	409.4	614.1	818.8	1024.	1228.	1433.	1638.	1842.	2047.	2457.	2866.	3275.
	I y-y	0.006	0.019	0.044	0.086	0.149	0.237	0.354	0.504	0.692	1.195	1.898	2.833
34½	Wt.	5.218	7.827	10.44	13.05	15.65	18.26	20.87	23.48	26.09	31.31	36.53	41.75
	Area	4.313	6.469	8.625	10.78	12.94	15.09	17.25	19.41	21.56	25.88	30.19	34.50
	I x-x	427.8	641.6	855.5	1069.	1283.	1497.	1711.	1925.	2139	2567.	2994.	3422.
	I y-y	0.006	0.019	0.045	0.088	0.152	0.241	0.359	0.512	0.702	1.213	1.926	2.875
35	Wt.	5.294	7.941	10.59	13.23	15.88	18.53	21.18	23.82	26.47	31.76	37.06	42.35
	Area	4.375	6.563	8.750	10.94	13.13	15.31	17.50	19.69	21.88	26.25	30.63	35.00
	I x-x	446.6	669.9	893.2	1117.	1340.	1563.	1786	2010	2233.	2680.	3126.	3573.
	I y-y	0.006	0.019	0.046	0.089	0.154	0.244	0.365	0.519	0.712	1.230	1.954	2.917
35½	Wt.	5.369	8.054	10.74	13.42	16.11	18.79	21.48	24.16	26.85	32.22	37.59	42.96
	Area	4.438	6.656	8.875	11.09	13.31	15.53	17.75	19.97	22.19	26.63	31.06	35.50
	I x-x	466.0	699.0	932.1	1165.	1398	1631.	1864.	2097.	2330	2796.	3262.	3728.
	I y-y	0.006	0.020	0.046	0.090	0.156	0.248	0.370	0.527	0.722	1.248	1.982	2.958



RECTANGLES

ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
36	Wt.	5.445	8.168	10.89	13.61	16.34	19.06	21.78	24.50	27.23	32.67	38.12	43.56
	Area	4.500	6.750	9.000	11.25	13.50	15.75	18.00	20.25	22.50	27.00	31.50	36.00
	I x-x	486.0	729.0	972.0	1215.	1458.	1701.	1944.	2187.	2430.	2916.	3402.	3888.
	I y-y	0.006	0.020	0.047	0.092	0.158	0.251	0.375	0.534	0.732	1.266	2.010	3.000
36½	Wt.	5.521	8.281	11.04	13.80	16.56	19.32	22.08	24.84	27.60	33.12	38.64	44.17
	Area	4.563	6.844	9.125	11.41	13.69	15.97	18.25	20.53	22.81	27.38	31.94	36.50
	I x-x	506.5	759.8	1013.	1266.	1520	1773.	2026.	2279.	2533.	3039.	3546.	4052.
	I y-y	0.006	0.020	0.048	0.093	0.160	0.255	0.380	0.541	0.743	1.283	2.038	3.042
37	Wt.	5.596	8.394	11.19	13.99	16.79	19.59	22.39	25.18	27.98	33.58	39.17	44.77
	Area	4.625	6.938	9.250	11.56	13.88	16.19	18.50	20.81	23.13	27.75	32.38	37.00
	I x-x	527.6	791.5	1055.	1319.	1583.	1847.	2111.	2374.	2638.	3166.	3693.	4221.
	I y-y	0.006	0.020	0.048	0.094	0.163	0.258	0.385	0.549	0.753	1.301	2.066	3.083
37½	Wt.	5.672	8.508	11.34	14.18	17.02	19.85	22.69	25.52	28.36	34.03	39.70	45.38
	Area	4.688	7.031	9.375	11.72	14.06	16.41	18.75	21.09	23.44	28.13	32.81	37.50
	I x-x	549.3	824.0	1099.	1373.	1648.	1923.	2197.	2472.	2747.	3296.	3845.	4395.
	I y-y	0.006	0.021	0.049	0.095	0.165	0.262	0.391	0.556	0.763	1.318	2.094	3.125
38	Wt.	5.748	8.621	11.50	14.37	17.24	20.12	22.99	25.86	28.74	34.49	40.23	45.98
	Area	4.750	7.125	9.500	11.88	14.25	16.63	19.00	21.38	23.75	28.50	33.25	38.00
	I x-x	571.6	857.4	1143.	1429.	1715.	2001.	2286.	2572.	2858.	3430.	4001.	4573.
	I y-y	0.006	0.021	0.049	0.097	0.167	0.265	0.396	0.564	0.773	1.336	2.121	3.167
38½	Wt.	5.823	8.735	11.65	14.56	17.47	20.38	23.29	26.20	29.12	34.94	40.76	46.59
	Area	4.813	7.219	9.625	12.03	14.44	16.84	19.25	21.66	24.06	28.88	33.69	38.50
	I x-x	594.4	891.7	1189.	1486.	1783.	2081.	2378.	2675.	2972.	3567.	4161.	4756.
	I y-y	0.006	0.021	0.050	0.098	0.169	0.269	0.401	0.571	0.783	1.354	2.149	3.208
39	Wt.	5.899	8.848	11.80	14.75	17.70	20.65	23.60	26.54	29.49	35.39	41.29	47.19
	Area	4.875	7.313	9.750	12.19	14.63	17.06	19.50	21.94	24.38	29.25	34.13	39.00
	I x-x	617.9	926.9	1236	1545.	1854.	2163.	2472.	2781.	3090.	3707.	4325.	4943.
	I y-y	0.006	0.021	0.051	0.099	0.171	0.272	0.406	0.578	0.793	1.371	2.177	3.250
39½	Wt.	5.974	8.962	11.95	14.94	17.92	20.91	23.90	26.88	29.87	35.85	41.82	47.80
	Area	4.938	7.406	9.875	12.34	14.81	17.28	19.75	22.22	24.69	29.63	34.56	39.50
	I x-x	642.0	963.0	1284	1605.	1926.	2247.	2568.	2889.	3210.	3852.	4494.	5136.
	I y-y	0.006	0.022	0.051	0.100	0.174	0.276	0.411	0.586	0.804	1.389	2.205	3.292

RECTANGLES

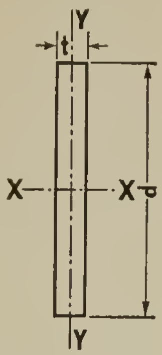
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in $in.^4$

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
40	Wt.	6.050	9.075	12.10	15.13	18.15	21.18	24.20	27.23	30.25	36.30	42.35	48.40
	Area	5.000	7.500	10.00	12.50	15.00	17.50	20.00	22.50	25.00	30.00	35.00	40.00
	I x-x	666.7	1000.	1333.	1667.	2000.	2333.	2667.	3000.	3333.	4000.	4667.	5333.
	I y-y	0.007	0.022	0.052	0.102	0.176	0.279	0.417	0.593	0.814	1.406	2.233	3.333
40½	Wt.	6.126	9.189	12.25	15.31	18.38	21.44	24.50	27.57	30.63	36.75	42.88	49.01
	Area	5.063	7.594	10.13	12.66	15.19	17.72	20.25	22.78	25.31	30.38	35.44	40.50
	I x-x	692.0	1038.	1384.	1730.	2076.	2422.	2768.	3114.	3460.	4152.	4844.	5536.
	I y-y	0.007	0.022	0.053	0.103	0.178	0 283	0.422	0.601	0.824	1.424	2.261	3.375
41	Wt.	6.201	9.302	12.40	15.50	18.60	21.70	24.81	27.91	31.01	37.21	43.41	49.61
	Area	5.125	7.688	10.25	12.81	15.38	17.94	20.50	23.06	25.63	30.75	35.88	41.00
	I x-x	717.9	1077.	1436.	1795.	2154.	2513.	2872.	3231.	3590.	4308.	5026.	5743.
	I y-y	0.007	0.023	0.053	0.104	0.180	0.286	0.427	0.608	0.834	1.441	2.289	3.417
41½	Wt.	6.277	9.416	12.55	15.69	18.83	21.97	25.11	28.25	31.38	37.66	43.94	50.22
	Area	5.188	7.781	10.38	12.97	15.56	18.16	20.75	23.34	25.94	31.13	36.31	41.50
	I x-x	744.5	1117.	1489.	1861.	2234.	2606.	2978.	3350.	3723.	4467.	5212.	5956.
	I y-y	0.007	0.023	0.054	0.106	0.182	0.290	0.432	0.616	0.844	1.459	2.317	3.458
42	Wt.	6.353	9.529	12.71	15.88	19.06	22.23	25.41	28.59	31.76	38.12	44.47	50.82
	Area	5.250	7.875	10.50	13.13	15.75	18.38	21.00	23.63	26.25	31.50	36.75	42.00
	I x-x	771.8	1158.	1544.	1929.	2315.	2701.	3087.	3473.	3859.	4631.	5402.	6174.
	I y-y	0.007	0.023	0.055	0.107	0.185	0.293	0.438	0.623	0.854	1.477	2.345	3.500
42½	Wt.	6.428	9.642	12.86	16.07	19.28	22.50	25.71	28.93	32.14	38.57	45.00	51.43
	Area	5.313	7.969	10.63	13.28	15.94	18.59	21.25	23.91	26.56	31.88	37.19	42.50
	I x-x	799.6	1199.	1599.	1999.	2399.	2799.	3199.	3598.	3998.	4798.	5598.	6397.
	I y-y	0.007	0.023	0.055	0.108	0.187	0.297	0.443	0.630	0.865	1.494	2.373	3.542
43	Wt.	6.504	9.756	13.01	16.26	19.51	22.76	26.02	29.27	32.52	39.02	45.53	52.03
	Area	5.375	8.063	10.75	13.44	16.13	18.81	21.50	24.19	26.88	32.25	37.63	43.00
	I x-x	828.2	1242.	1656.	2070.	2485.	2899.	3313.	3727.	4141.	4969.	5797.	6626.
	I y-y	0.007	0.024	0.056	0.109	0.189	0.300	0.448	0.638	0.875	1.512	2.401	3.583
43½	Wt.	6.579	9.869	13.16	16.45	19.74	23.03	26.32	29.61	32.90	39.48	46.06	52.64
	Area	5.438	8.156	10.88	13.59	16.31	19.03	21.75	24.47	27.19	32.63	38.06	43.50
	I x-x	857.4	1286.	1715.	2144.	2572.	3001.	3430.	3858.	4287.	5145.	6002.	6859.
	I y-y	0.007	0.024	0.057	0.111	0.191	0.304	0.453	0.645	0.885	1.529	2.428	3.625



RECTANGLES

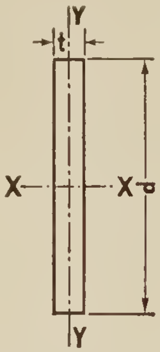
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
44	Wt.	6.655	9.983	13.31	16.64	19.97	23.29	26.62	29.95	33.28	39.93	46.59	53.24
	Area	5.500	8.250	11.00	13.75	16.50	19.25	22.00	24.75	27.50	33.00	38.50	44.00
	I x-x	887.3	1331.	1775.	2218.	2662.	3106.	3549.	3993.	4437.	5324.	6211.	7099.
	I y-y	0.007	0.024	0.057	0.112	0.193	0.307	0.458	0.653	0.895	1.547	2.456	3.667
44½	Wt.	6.731	10.10	13.46	16.83	20.19	23.56	26.92	30.29	33.65	40.38	47.11	53.85
	Area	5.563	8.344	11.13	13.91	16.69	19.47	22.25	25.03	27.81	33.38	38.94	44.50
	I x-x	917.9	1377.	1836.	2295.	2754.	3213.	3672.	4131.	4590.	5508.	6426.	7343.
	I y-y	0.007	0.024	0.058	0.113	0.196	0.311	0.464	0.660	0.905	1.564	2.484	3.708
45	Wt.	6.806	10.21	13.61	17.02	20.42	23.82	27.23	30.63	34.03	40.84	47.64	54.45
	Area	5.625	8.438	11.25	14.06	16.88	19.69	22.50	25.31	28.13	33.75	39.38	45.00
	I x-x	949.2	1424.	1898.	2373.	2848.	3322.	3797.	4271.	4746.	5695.	6645.	7594.
	I y-y	0.007	0.025	0.059	0.114	0.198	0.314	0.469	0.667	0.916	1.582	2.512	3.750
45½	Wt.	6.882	10.32	13.76	17.20	20.65	24.09	27.53	30.97	34.41	41.29	48.17	55.06
	Area	5.688	8.531	11.38	14.22	17.06	19.91	22.75	25.59	28.44	34.13	39.81	45.50
	I x-x	981.2	1472.	1962.	2453.	2944.	3434.	3925.	4415.	4906.	5887.	6868.	7850.
	I y-y	0.007	0.025	0.059	0.116	0.200	0.318	0.474	0.675	0.926	1.600	2.540	3.792
46	Wt.	6.958	10.44	13.92	17.39	20.87	24.35	27.83	31.31	34.79	41.75	48.70	55.66
	Area	5.750	8.625	11.50	14.38	17.25	20.13	23.00	25.88	28.75	34.50	40.25	46.00
	I x-x	1014.	1521.	2028.	2535.	3042.	3549.	4056.	4563.	5070.	6084.	7097.	8111.
	I y-y	0.007	0.025	0.060	0.117	0.202	0.321	0.479	0.682	0.936	1.617	2.568	3.833
46½	Wt.	7.033	10.55	14.07	17.58	21.10	24.62	28.13	31.65	35.17	42.20	49.23	56.27
	Area	5.813	8.719	11.63	14.53	17.44	20.34	23.25	26.16	29.06	34.88	40.69	46.50
	I x-x	1047.	1571.	2095.	2618.	3142.	3666.	4189.	4713.	5237.	6284.	7331.	8379.
	I y-y	0.008	0.026	0.061	0.118	0.204	0.324	0.484	0.690	0.946	1.635	2.596	3.875
47	Wt.	7.109	10.66	14.22	17.77	21.33	24.88	28.44	31.99	35.54	42.65	49.76	56.87
	Area	5.875	8.813	11.75	14.69	17.63	20.56	23.50	26.44	29.38	35.25	41.13	47.00
	I x-x	1081.	1622.	2163.	2704.	3244.	3785.	4326.	4867.	5407.	6489.	7570.	8652.
	I y-y	0.008	0.026	0.061	0.120	0.207	0.328	0.490	0.697	0.956	1.652	2.624	3.917
48	Wt.	7.260	10.89	14.52	18.15	21.78	25.41	29.04	32.67	36.30	43.56	50.82	58.08
	Area	6.000	9.000	12.00	15.00	18.00	21.00	24.00	27.00	30.00	36.00	42.00	48.00
	I x-x	1152.	1728.	2304.	2880.	3456.	4032.	4608.	5184.	5760.	6912.	8064.	9216.
	I y-y	0.008	0.026	0.063	0.122	0.211	0.335	0.500	0.712	0.977	1.687	2.680	4.000



RECTANGLES

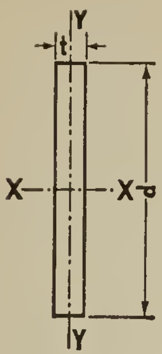
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.[4]

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		⅛	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1
49	Wt.	7.411	11.12	14.82	18.53	22.23	25.94	29.65	33.35	37.06	44.47	51.88	59.29
	Area	6.125	9.188	12.25	15.31	18.38	21.44	24.50	27.56	30.63	36.75	42.88	49.00
	I x-x	1226.	1838.	2451.	3064.	3677.	4289.	4902.	5515.	6128.	7353.	8579.	9804.
	I y-y	0.008	0.027	0.064	0.125	0.215	0.342	0.510	0.727	0.997	1.723	2.736	4.083
50	Wt.	7.563	11.34	15.13	18.91	22.69	26.47	30.25	34.03	37.81	45.38	52.94	60.50
	Area	6.250	9.375	12.50	15.63	18.75	21.88	25.00	28.13	31.25	37.50	43.75	50.00
	I x-x	1302.	1953.	2604.	3255.	3906.	4557.	5208.	5859.	6510.	7813.	9115.	10417
	I y-y	0.008	0.027	0.065	0.127	0.220	0.349	0.521	0.742	1.017	1.758	2.791	4.167
51	Wt.	7.714	11.57	15.43	19.28	23.14	27.00	30.86	34.71	38.57	46.28	54.00	61.71
	Area	6.375	9.563	12.75	15.94	19.13	22.31	25.50	28.69	31.88	38.25	44.63	51.00
	I x-x	1382.	2073.	2764.	3454.	4145.	4836.	5527.	6218.	6909.	8291.	9672.	11054
	I y-y	0.008	0.028	0.066	0.130	0.224	0.356	0.531	0.756	1.038	1.793	2.847	4.250
52	Wt.	7.865	11.80	15.73	19.66	23.60	27.53	31.46	35.39	39.33	47.19	55.06	62.92
	Area	6.500	9.750	13.00	16.25	19.50	22.75	26.00	29.25	32.50	39.00	45.50	52.00
	I x-x	1465.	2197.	2929.	3662.	4394.	5126.	5859.	6591.	7323.	8788.	10253	11717
	I y-y	0.008	0.029	0.068	0.132	0.229	0.363	0.542	0.771	1.058	1.828	2.903	4.333
53	Wt.	8.016	12.02	16.03	20.04	24.05	28.06	32.07	36.07	40.08	48.10	56.11	64.13
	Area	6.625	9.938	13.25	16.56	19.88	23.19	26.50	29.81	33.13	39.75	46.38	53.00
	I x-x	1551.	2326.	3102.	3877.	4652.	5428.	6203.	6979.	7754.	9305.	10856	12406
	I y-y	0.009	0.029	0.069	0.135	0.233	0.370	0.552	0.786	1.078	1.863	2.959	4.417
54	Wt.	8.168	12.25	16.34	20.42	24.50	28.59	32.67	36.75	40.84	49.01	57.17	65.34
	Area	6.750	10.13	13.50	16.88	20.25	23.63	27.00	30.38	33.75	40.50	47.25	54.00
	I x-x	1640.	2460.	3281.	4101.	4921.	5741.	6561.	7381.	8201.	9842.	11482	13122
	I y-y	0.009	0.030	0.070	0.137	0.237	0.377	0.563	0.801	1.099	1.898	3.015	4.500
55	Wt.	8.319	12.48	16.64	20.80	24.96	29.12	33.28	37.43	41.59	49.91	58.23	66.55
	Area	6.875	10.31	13.75	17.19	20.63	24.06	27.50	30.94	34.38	41.25	48.13	55.00
	I x-x	1733.	2600.	3466.	4333.	5199.	6066.	6932.	7799.	8665.	10398	12132	13865
	I y-y	0.009	0.030	0.072	0.140	0.242	0.384	0.573	0.816	1.119	1.934	3.070	4.583
56	Wt.	8.470	12.71	16.94	21.18	25.41	29.65	33.88	38.12	42.35	50.82	59.29	67.76
	Area	7.000	10.50	14.00	17.50	21.00	24.50	28.00	31.50	35.00	42.00	49.00	56.00
	I x-x	1829.	2744.	3659.	4573.	5488.	6403.	7317.	8232.	9147.	10976	12805	14635
	I y-y	0.009	0.031	0.073	0.142	0.246	0.391	0.583	0.831	1.139	1.969	3.126	4.667



RECTANGLES

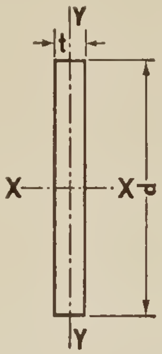
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
57	Wt.	8.621	12.93	17.24	21.55	25.86	30.17	34.49	38.80	43.11	51.73	60.35	68.97
	Area	7.125	10.69	14.25	17.81	21.38	24.94	28.50	32.06	35.63	42.75	49.88	57.00
	I x-x	1929.	2894.	3858.	4823.	5787.	6752.	7716.	8681.	9645.	11575	13504	15433
	I y-y	0.009	0.031	0.074	0.145	0.250	0.398	0.594	0.845	1.160	2.004	3.182	4.750
58	Wt.	8.773	13.16	17.55	21.93	26.32	30.70	35.09	39.48	43.86	52.64	61.41	70.18
	Area	7.250	10.88	14.50	18.13	21.75	25.38	29.00	32.63	36.25	43.50	50.75	58.00
	I x-x	2032.	3049.	4065.	5081.	6097.	7113.	8130.	9146.	10162	12195	14227	16259
	I y-y	0.009	0.032	0.076	0.148	0.255	0.405	0.604	0.860	1.180	2.039	3.238	4.833
59	Wt.	8.924	13.39	17.85	22.31	26.77	31.23	35.70	40.16	44.62	53.54	62.47	71.39
	Area	7.375	11.06	14.75	18.44	22.13	25.81	29.50	33.19	36.88	44.25	51.63	59.00
	I x-x	2139.	3209.	4279.	5348.	6418.	7488.	8557.	9627.	10697	12836	14976	17115
	I y-y	0.010	0.032	0.077	0.150	0.259	0.412	0.615	0.875	1.200	2.074	3.294	4.917
60	Wt.	9.075	13.61	18.15	22.69	27.23	31.76	36.30	40.84	45.38	54.45	63.53	72.60
	Area	7.500	11.25	15.00	18.75	22.50	26.25	30.00	33.75	37.50	45.00	52.50	60.00
	I x-x	2250.	3375.	4500.	5625.	6750.	7875.	9000.	10125	11250	13500	15750	18000
	I y-y	0.010	0.033	0.078	0.153	0.264	0.419	0.625	0.890	1.221	2.109	3.350	5.000
61	Wt.	9.226	13.84	18.45	23.07	27.68	32.29	36.91	41.52	46.13	55.36	64.58	73.81
	Area	7.625	11.44	15.25	19.06	22.88	26.69	30.50	34.31	38.13	45.75	53.38	61.00
	I x-x	2364.	3547.	4729.	5911.	7093.	8275.	9458.	10640	11822	14186	16551	18915
	I y-y	0.010	0.034	0.079	0.155	0.268	0.426	0.635	0.905	1.241	2.145	3.405	5.083
62	Wt.	9.378	14.07	18.76	23.44	28.13	32.82	37.51	42.20	46.89	56.27	65.64	75.02
	Area	7.750	11.63	15.50	19.38	23.25	27.13	31.00	34.88	38.75	46.50	54.25	62.00
	I x-x	2483.	3724.	4965.	6206.	7448.	8689.	9930.	11172	12413	14896	17378	19861
	I y-y	0.010	0.034	0.081	0.158	0.272	0.433	0.646	0.920	1.261	2.180	3.461	5.167
63	Wt.	9.529	14.29	19.06	23.82	28.59	33.35	38.12	42.88	47.64	57.17	66.70	76.23
	Area	7.875	11.81	15.75	19.69	23.63	27.56	31.50	35.44	39.38	47.25	55.13	63.00
	I x-x	2605.	3907.	5209.	6512.	7814.	9116.	10419	11721	13023	15628	18233	20837
	I y-y	0.010	0.035	0.082	0.160	0.277	0.440	0.656	0.934	1.282	2.215	3.517	5.250
64	Wt.	9.680	14.52	19.36	24.20	29.04	33.88	38.72	43.56	48.40	58.08	67.76	77.44
	Area	8.000	12.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00	48.00	56.00	64.00
	I x-x	2731.	4096.	5461.	6827.	8192.	9557.	10923	12288	13653	16384	19115	21845
	I y-y	0.010	0.035	0.083	0.163	0.281	0.447	0.667	0.949	1.302	2.250	3.573	5.333



RECTANGLES

ELEMENTS OF SECTIONS

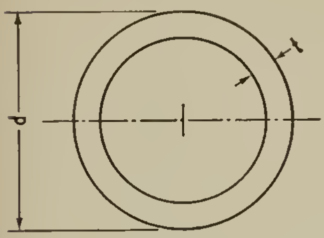
All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
65	Wt.	9.831	14.75	19.66	24.58	29.49	34.41	39.33	44.24	49.16	58.99	68.82	78.65
	Area	8.125	12.19	16.25	20.31	24.38	28.44	32.50	36.56	40.63	48.75	56.88	65.00
	I x-x	2861.	4291.	5721.	7152.	8582.	10012	11443	12873	14303	17164	20025	22885
	I y-y	0.011	0.036	0.085	0.165	0.286	0.454	0.677	0.964	1.322	2.285	3.629	5.417
66	Wt.	9.983	14.97	19.97	24.96	29.95	34.94	39.93	44.92	49.91	59.90	69.88	79.86
	Area	8.250	12.38	16.50	20.63	24.75	28.88	33.00	37.13	41.25	49.50	57.75	66.00
	I x-x	2995.	4492.	5990.	7487.	8984.	10482	11979	13476	14974	17969	20963	23958
	I y-y	0.011	0.036	0.086	0.168	0.290	0.461	0.688	0.979	1.343	2.320	3.685	5.500
67	Wt.	10.13	15.20	20.27	25.33	30.40	35.47	40.54	45.60	50.67	60.80	70.94	81.07
	Area	8.375	12.56	16.75	20.94	25.13	29.31	33.50	37.69	41.88	50.25	58.63	67.00
	I x-x	3133.	4699.	6266.	7832.	9399.	10965	12532	14098	15665	18798	21931	25064
	I y-y	0.011	0.037	0.087	0.170	0.294	0.468	0.698	0.994	1.363	2.355	3.740	5.583
68	Wt.	10.29	15.43	20.57	25.71	30.86	36.00	41.14	46.28	51.43	61.71	72.00	82.28
	Area	8.500	12.75	17.00	21.25	25.50	29.75	34.00	38.25	42.50	51.00	59.50	68.00
	I x-x	3275.	4913.	6551.	8188.	9826.	11464	13101	14739	16377	19652	22927	26203
	I y-y	0.011	0.037	0.089	0.173	0.299	0.475	0.708	1.009	1.383	2.391	3.796	5.667
69	Wt.	10.44	15.65	20.87	26.09	31.31	36.53	41.75	46.96	52.18	62.62	73.05	83.49
	Area	8.625	12.94	17.25	21.56	25.88	30.19	34.50	38.81	43.13	51.75	60.38	69.00
	I x-x	3422.	5133.	6844.	8555.	10266	11977	13688	15399	17110	20532	23954	27376
	I y-y	0.011	0.038	0.090	0.175	0.303	0.482	0.719	1.023	1.404	2.426	3.852	5.750
70	Wt.	10.59	15.88	21.18	26.47	31.76	37.06	42.35	47.64	52.94	63.53	74.11	84.70
	Area	8.750	13.13	17.50	21.88	26.25	30.63	35.00	39.38	43.75	52.50	61.25	70.00
	I x-x	3573.	5359.	7146.	8932.	10719	12505	14292	16078	17865	21438	25010	28583
	I y-y	0.011	0.038	0.091	0.178	0.308	0.488	0.729	1.038	1.424	2.461	3.908	5.833
71	Wt.	10.74	16.11	21.48	26.85	32.22	37.59	42.96	48.32	53.69	64.43	75.17	85.91
	Area	8.875	13.31	17.75	22.19	26.63	31.06	35.50	39.94	44.38	53.25	62.13	71.00
	I x-x	3728.	5592.	7456.	9321.	11185	13049	14913	16777	18641	22369	26098	29826
	I y-y	0.012	0.039	0.092	0.181	0.312	0.495	0.740	1.053	1.444	2.496	3.964	5.917
72	Wt.	10.89	16.34	21.78	27.23	32.67	38.12	43.56	49.01	54.45	65.34	76.23	87.12
	Area	9.000	13.50	18.00	22.50	27.00	31.50	36.00	40.50	45.00	54.00	63.00	72.00
	I x-x	3888.	5832.	7776.	9720.	11664	13608	15552	17496	19440	23328	27216	31104
	I y-y	0.012	0.040	0.094	0.183	0.316	0.502	0.750	1.068	1.465	2.531	4.020	6.000

ROUND TUBING



ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.

I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.

Diameter, d	1/2					3/4				
Thickness, t	1/32	1/16	3/32	1/8	5/32	1/32	1/16	3/32	1/8	3/16
Weight	0.056	0.104	0.145	0.178	0.204	0.085	0.163	0.234	0.297	0.401
Area	0.046	0.086	0.120	0.147	0.169	0.071	0.135	0.193	0.245	0.331
I	0.001	0.002	0.003	0.003	0.003	0.005	0.008	0.011	0.012	0.015
S	0.005	0.008	0.010	0.012	0.012	0.012	0.021	0.028	0.033	0.039
r	0.166	0.156	0.147	0.140	0.134	0.254	0.244	0.234	0.225	0.210

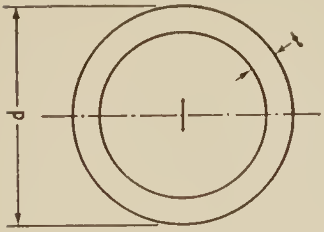
10

Diameter, d	1					1 1/4				
Thickness, t	1/32	1/16	1/8	3/16	1/4	1/32	1/16	1/8	3/16	1/4
Weight	0.115	0.223	0.416	0.579	0.713	0.145	0.282	0.535	0.757	0.950
Area	0.095	0.184	0.344	0.479	0.589	0.120	0.233	0.442	0.626	0.785
I	0.011	0.020	0.034	0.042	0.046	0.022	0.041	0.071	0.091	0.104
S	0.022	0.041	0.067	0.083	0.092	0.036	0.066	0.113	0.146	0.167
r	0.342	0.332	0.313	0.295	0.280	0.431	0.420	0.400	0.381	0.364

Diameter, d	1 1/2					1 3/4				
Thickness, t	1/32	1/16	1/8	3/16	1/4	1/32	1/16	1/8	3/16	1/4
Weight	0.175	0.342	0.653	0.936	1.188	0.204	0.401	0.772	1.114	1.426
Area	0.144	0.282	0.540	0.773	0.982	0.169	0.331	0.638	0.920	1.178
I	0.039	0.073	0.129	0.170	0.199	0.062	0.118	0.212	0.285	0.341
S	0.052	0.097	0.172	0.227	0.266	0.071	0.135	0.242	0.326	0.389
r	0.519	0.509	0.488	0.469	0.451	0.608	0.597	0.576	0.556	0.538

Diameter, d	2					2 1/4				
Thickness, t	1/16	1/8	3/16	1/4	5/16	1/16	1/8	3/16	1/4	5/16
Weight	0.460	0.891	1.292	1.663	2.005	0.520	1.010	1.470	1.901	2.302
Area	0.380	0.736	1.068	1.374	1.657	0.430	0.834	1.215	1.571	1.902
I	0.179	0.325	0.443	0.537	0.610	0.257	0.473	0.651	0.798	0.916
S	0.179	0.325	0.443	0.537	0.610	0.229	0.420	0.579	0.709	0.814
r	0.685	0.664	0.644	0.625	0.607	0.774	0.753	0.732	0.713	0.694

ROUND TUBING



ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.

I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.

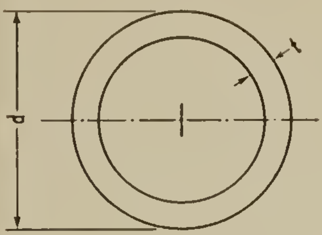
Diameter, d	2½					2¾				
Thickness, t	1/16	1/8	3/16	1/4	5/16	1/16	1/8	3/16	1/4	5/16
Weight	0.579	1.129	1.648	2.138	2.599	0.639	1.247	1.827	2.376	2.896
Area	0.479	0.933	1.362	1.767	2.148	0.528	1.031	1.510	1.964	2.393
I	0.356	0.660	0.917	1.132	1.311	0.477	0.890	1.246	1.549	1.807
S	0.285	0.528	0.733	0.906	1.049	0.347	0.647	0.906	1.127	1.314
r	0.862	0.841	0.820	0.800	0.781	0.950	0.929	0.908	0.888	0.869

Diameter, d	3					3¼				
Thickness, t	1/8	3/16	1/4	5/16	3/8	1/8	3/16	1/4	5/16	3/8
Weight	1.366	2.005	2.614	3.193	3.742	1.485	2.183	2.851	3.490	4.098
Area	1.129	1.657	2.160	2.639	3.093	1.227	1.804	2.356	2.884	3.387
I	1.169	1.646	2.059	2.414	2.718	1.501	2.123	2.669	3.146	3.559
S	0.779	1.097	1.373	1.610	1.812	0.923	1.306	1.643	1.936	2.190
r	1.017	0.997	0.976	0.957	0.938	1.106	1.085	1.064	1.044	1.025

Diameter, d	3½					3¾				
Thickness, t	1/8	3/16	1/4	5/16	3/8	1/8	3/16	1/4	5/16	3/8
Weight	1.604	2.361	3.089	3.787	4.455	1.722	2.539	3.326	4.084	4.811
Area	1.325	1.951	2.553	3.129	3.682	1.424	2.099	2.749	3.375	3.976
I	1.890	2.685	3.390	4.013	4.559	2.341	3.339	4.231	5.026	5.732
S	1.080	1.534	1.937	2.293	2.605	1.249	1.781	2.256	2.681	3.057
r	1.194	1.173	1.153	1.132	1.113	1.282	1.261	1.241	1.220	1.201

Diameter, d	4					4¼				
Thickness, t	1/8	3/16	1/4	5/16	3/8	1/8	3/16	1/4	5/16	3/8
Weight	1.841	2.717	3.564	4.380	5.167	1.960	2.896	3.801	4.678	5.524
Area	1.522	2.246	2.945	3.620	4.271	1.620	2.393	3.142	3.866	4.565
I	2.859	4.090	5.200	6.198	7.090	3.449	4.948	6.308	7.539	8.649
S	1.429	2.045	2.600	3.098	3.544	1.623	2.328	2.968	3.548	4.070
r	1.371	1.350	1.329	1.308	1.289	1.459	1.438	1.417	1.397	1.376

ROUND TUBING



ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.

I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.

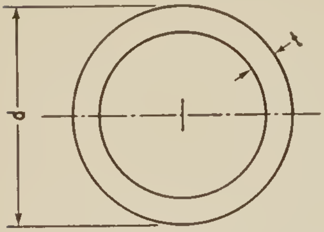
Diameter, d	4½					4¾				
Thickness, t	⅛	3/16	¼	5/16	⅜	⅛	3/16	¼	5/16	⅜
Weight	2.079	3.074	4.039	4.974	5.880	2.198	3.252	4.277	5.271	6.237
Area	1.718	2.540	3.338	4.111	4.860	1.816	2.688	3.534	4.357	5.154
I	4.114	5.917	7.563	9.062	10.42	4.860	7.006	8.975	10.78	12.42
S	1.829	2.630	3.362	4.028	4.633	2.047	2.950	3.779	4.538	5.231
r	1.547	1.526	1.505	1.485	1.464	1.636	1.615	1.594	1.573	1.553

Diameter, d	5					5¼				
Thickness, t	3/16	¼	5/16	⅜	7/16	3/16	¼	5/16	⅜	7/16
Weight	3.430	4.514	5.568	6.593	7.588	3.608	4.752	5.865	6.949	8.004
Area	2.835	3.731	4.602	5.449	6.271	2.982	3.927	4.847	5.743	6.615
I	8.220	10.55	12.70	14.67	16.47	9.568	12.30	14.83	17.16	19.31
S	3.288	4.220	5.078	5.866	6.587	3.645	4.687	5.650	6.538	7.356
r	1.703	1.682	1.661	1.641	1.621	1.791	1.770	1.749	1.729	1.709

Diameter, d	5½					6				
Thickness, t	3/16	¼	5/16	⅜	7/16	3/16	¼	5/16	⅜	½
Weight	3.787	4.989	6.162	7.306	8.419	4.143	5.465	6.756	8.018	10.45
Area	3.129	4.123	5.093	6.038	6.958	3.424	4.516	5.584	6.627	8.639
I	11.05	14.24	17.19	19.93	22.46	14.47	18.70	22.65	26.33	32.94
S	4.020	5.178	6.252	7.247	8.166	4.825	6.232	7.547	8.774	10.98
r	1.879	1.858	1.837	1.817	1.797	2.056	2.035	2.014	1.993	1.953

Diameter, d	6½					7				
Thickness, t	3/16	¼	5/16	⅜	½	3/16	¼	5/16	⅜	½
Weight	4.499	5.940	7.350	8.731	11.40	4.856	6.415	7.944	9.444	12.35
Area	3.718	4.909	6.075	7.216	9.425	4.013	5.302	6.566	7.805	10.21
I	18.54	24.01	29.15	33.97	42.71	23.30	30.23	36.78	42.96	54.24
S	5.703	7.385	8.966	10.45	13.14	6.656	8.638	10.51	12.27	15.50
r	2.233	2.212	2.190	2.170	2.129	2.410	2.388	2.367	2.346	2.305

ROUND TUBING



ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.

I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.

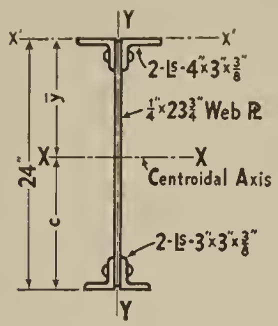
Diameter, d	7½					8				
Thickness, t	3/16	1/4	5/16	3/8	1/2	3/16	1/4	5/16	3/8	1/2
Weight	5.212	6.890	8.538	10.16	13.31	5.568	7.365	9.132	10.87	14.26
Area	4.307	5.694	7.056	8.394	11.00	4.602	6.087	7.547	8.983	11.78
I	28.81	37.46	45.66	53.42	67.70	35.13	45.75	55.84	65.45	83.21
S	7.683	9.989	12.18	14.24	18.05	8.780	11.43	13.96	16.36	20.80
r	2.586	2.565	2.544	2.523	2.481	2.763	2.742	2.720	2.699	2.658

Diameter, d	8½					9				
Thickness, t	3/16	1/4	5/16	3/8	1/2	3/16	1/4	5/16	3/8	1/2
Weight	5.924	7.840	9.726	11.58	15.21	6.281	8.316	10.32	12.29	16.16
Area	4.896	6.480	8.038	9.572	12.57	5.191	6.872	8.529	10.16	13.35
I	42.32	55.18	67.45	79.16	100.9	50.42	65.82	80.57	94.67	121.0
S	9.956	12.98	15.87	18.63	23.75	11.20	14.63	17.91	21.04	26.89
r	2.940	2.918	2.897	2.876	2.834	3.116	3.095	3.074	3.052	3.010

Diameter, d	9½					10				
Thickness, t	3/16	1/4	5/16	3/8	1/2	3/16	1/4	5/16	3/8	1/2
Weight	6.637	8.791	10.91	13.01	17.11	6.994	9.266	11.51	13.72	18.06
Area	5.485	7.265	9.020	10.75	14.14	5.780	7.658	9.510	11.34	14.92
I	59.49	77.76	95.28	112.1	143.6	69.59	91.06	111.7	131.5	168.8
S	12.52	16.36	20.05	23.59	30.22	13.92	18.21	22.34	26.30	33.76
r	3.293	3.272	3.250	3.229	3.187	3.470	3.448	3.427	3.406	3.363

Diameter, d	10½					11				
Thickness, t	3/16	1/4	5/16	3/8	1/2	3/16	1/4	5/16	3/8	1/2
Weight	7.350	9.741	12.10	14.43	19.01	7.706	10.22	12.70	15.14	19.96
Area	6.074	8.050	10.00	11.93	15.71	6.369	8.443	10.49	12.52	16.49
I	80.78	105.8	129.9	153.1	196.8	93.10	122.0	149.9	176.9	227.8
S	15.39	20.15	24.74	29.15	37.49	16.93	22.19	27.26	32.16	41.42
r	3.647	3.625	3.604	3.582	3.540	3.823	3.802	3.780	3.759	3.717

PLATE GIRDER



ELEMENTS OF SECTION

These are typical calculations for the various elements of a section of a plate girder. They include not only the ordinary values: area, moment of inertia, and section modulus, but also torsional moment of inertia, J, and moment of inertia of compression flange, I_F. The latter values are needed for determining critical buckling stress of compression flange, see page 48.

Section	Weight	Area (gross)	About axis X'-X'				About axis Y-Y			J[1]
			y	Ay	Ay^2	I_o	x	Ax^2	I_o	
2 ∠ 4″×3″×3/8″....	6.02	4.98	0.77	3.8	3	4	1.39	9.6	7.8	0.246
1 PL 1/4″×23 3/4″....	7.18	5.94	12.00	71.3	855	279	0.00	0.0	0.0	0.124
2 ∠ 3″×3″×3/8″....	5.10	4.20	23.13	97.1	2247	3	1.00	4.2	3.4	0.210
	18.30	15.12		172.2	3105	286		13.8	11.2	0.580

[1]Torsion factor. Values for angles taken from pages 93 and 94. Values for plate obtained according to formula on page 49: $\frac{1}{3} \times 23.75 \times \overline{0.25}^3 = 0.124$

Weight = 18.30 lb./ft.

Area = 15.12 sq. in.

$$\bar{y} = \frac{172.2}{15.12} = 11.4 \text{ inches}$$

$$c = 24 - 11.4 = 12.6 \text{ inches}$$

$$I_X = 3105 + 286 - 172.2 \times 11.4 = 1430 \text{ in.}^4$$

$$I_Y = 13.8 + 11.2 = 25.0 \text{ in.}^4$$

$$S \text{ (top flange)} = \frac{1430}{11.4} = 125 \text{ in.}^3$$

$$S \text{ (bottom flange)} = \frac{1430}{12.6} = 114 \text{ in.}^3 \text{ (See note.)}$$

$$J = 0.580 \text{ in.}^4$$

I_F (moment of inertia of compression flange about axis Y) $= 9.6 + 7.8 = 17.4$ in.^{4}

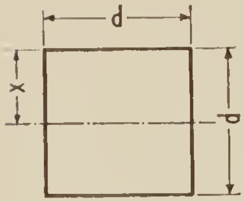
Note.—These section elements are based on gross area and therefore the section modulus values divided into any given bending moment give extreme fiber stresses based on gross area. To obtain the stresses based on net area, multiply gross stress by ratio of gross to net area. Thus the bottom flange stress in this girder, based on net area, assuming 21/32 in. rivet holes, is:

$$\frac{M}{114} \times \frac{4.20}{4.20 - 0.49} = \frac{M}{114} \times 1.13$$

FORMULAS

TABLE 22—FORMULAS FOR ELEMENTS OF SECTIONS

Figure 1



$A = d^2$

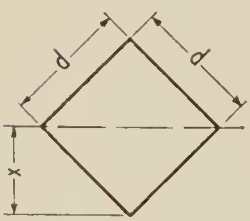
$x = \frac{d}{2}$

$I = \frac{d^4}{12}$

$S = \frac{d^3}{6}$

$r = \frac{d}{\sqrt{12}} = 0.2887d$

Figure 2



$A = d^2$

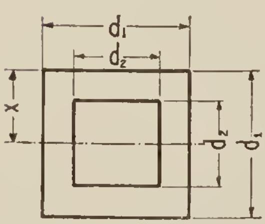
$x = \frac{d}{\sqrt{2}} = 0.7071d$

$I = \frac{d^4}{12}$

$S = \frac{\sqrt{2}\,d^3}{12} = 0.1179d^3$

$r = \frac{d}{\sqrt{12}} = 0.2887d$

Figure 3



$A = d_1^2 - d_2^2$

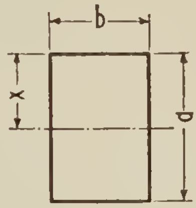
$x = \frac{d_1}{2}$

$I = \frac{d_1^4 - d_2^4}{12}$

$S = \frac{d_1^4 - d_2^4}{6d_1}$

$r = \sqrt{\frac{d_1^2 + d_2^2}{12}}$

Figure 4



$A = bd$

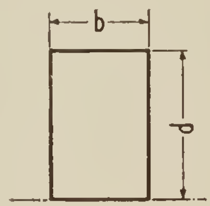
$x = \frac{d}{2}$

$I = \frac{bd^3}{12}$

$S = \frac{bd^2}{6}$

$r = \frac{d}{\sqrt{12}} = 0.2887d$

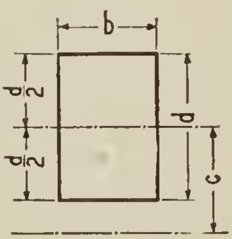
Figure 5



$A = bd$

$I = \frac{bd^3}{3}$

Figure 6

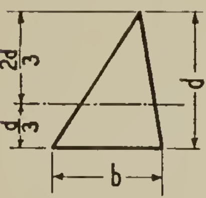


$A = bd$

$I = A\left(\frac{d^2}{12} + c^2\right)$

TABLE 22—FORMULAS FOR ELEMENTS OF SECTIONS—Continued

Figure 7



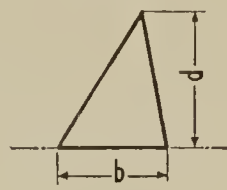
$$A = \frac{bd}{2}$$

$$I = \frac{bd^3}{36}$$

$$S = \frac{bd^2}{24}$$

$$r = \frac{d}{\sqrt{18}} = 0.2357d$$

Figure 8

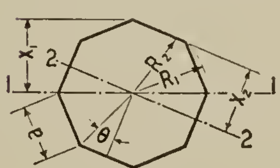


$$A = \frac{bd}{2}$$

$$I = \frac{bd^3}{12}$$

Figure 9

Regular Polygon



n = Number of Sides

$$a = 2\sqrt{R_1^2 - R_2^2} \quad , \Theta = \frac{180°}{n}$$

$$A = \frac{na^2 \cot \Theta}{4} = \frac{nR_1^2 \sin 2\Theta}{2} = nR_2^2 \tan \Theta$$

$$x_1 = R_1 = \frac{a}{2 \sin \Theta}, \quad x_2 = R_2 = \frac{a}{2 \tan \Theta}$$

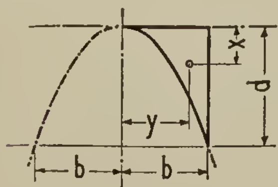
$$I_{1\text{-}1} = I_{2\text{-}2} = \frac{A\,(6R_1^2 - a^2)}{24} = \frac{A\,(12R_2^2 + a^2)}{48}$$

$$S_{1\text{-}1} = \frac{A\,(6R_1^2 - a^2)}{24R_1}, \quad S_{2\text{-}2} = \frac{A\,(12R_2^2 + a^2)}{48R_2}$$

$$r_{1\text{-}1} = \sqrt{\frac{6R_1^2 - a^2}{24}}, \quad r_{2\text{-}2} = \sqrt{\frac{12R_2^2 + a^2}{48}}$$

Figure 10

Parabola: $y = -ax^2$



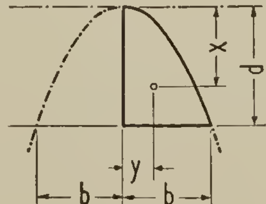
$$A = \frac{bd}{3}$$

$$x = \frac{3d}{10}$$

$$y = \frac{3b}{4}$$

Figure 11

Parabola: $y = -ax^2$



$$A = \frac{2\,bd}{3}$$

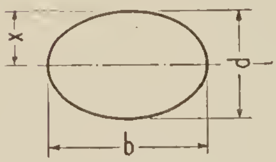
$$x = \frac{6d}{10}$$

$$y = \frac{3b}{8}$$

TABLE 22—FORMULAS FOR ELEMENTS OF SECTIONS—Concluded

Figure 12

Ellipse



$$A = \frac{\pi\ bd}{4}$$

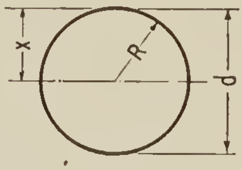
$$x = \frac{d}{2}$$

$$I = \frac{\pi\ bd^3}{64}$$

$$S = \frac{\pi\ bd^2}{32}$$

$$r = \frac{d}{4}$$

Figure 13



$$A = \pi\ R^2 = \frac{\pi d^2}{4}$$

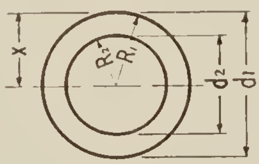
$$x = R = \frac{d}{2}$$

$$I = \frac{\pi R^4}{4} = \frac{\pi d^4}{64}$$

$$S = \frac{\pi R^3}{4} = \frac{\pi d^3}{32}$$

$$r = \frac{R}{2} = \frac{d}{4}$$

Figure 14



$$A = \pi\ (R_1^{\,2} - R_2^{\,2}) = \frac{\pi(d_1^{\,2} - d_2^{\,2})}{4}$$

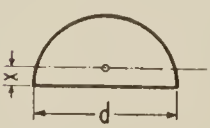
$$x = R_1 = \frac{d_1}{2}$$

$$I = \frac{\pi(R_1^{\,4} - R_2^{\,4})}{4} = \frac{\pi(d_1^{\,4} - d_2^{\,4})}{64}$$

$$S = \frac{\pi(R_1^{\,4} - R_2^{\,4})}{4R_1} = \frac{\pi(d_1^{\,4} - d_2^{\,4})}{32d_1}$$

$$r = \sqrt{\frac{R_1^{\,2} + R_2^{\,2}}{4}} = \sqrt{\frac{d_1^{\,2} + d_2^{\,2}}{16}}$$

Figure 15



$$A = \frac{\pi R^2}{2} = \frac{\pi d^2}{8}$$

$$I = 0.1098R^4 = 0.0069d^4$$

$$x = \frac{4R}{3\pi} = \frac{2d}{3\pi}$$

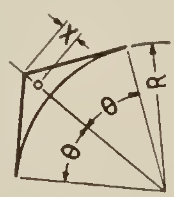


Figure 16

$$A = (\tan\Theta - \Theta)R^2$$

$$x = \left(\sec\Theta - \frac{\tan^2\Theta\sin\Theta}{3(\tan\Theta - \Theta)}\right)R$$

TECHNICAL DATA

ON

MISCELLANEOUS STRUCTURAL

PRODUCTS

TABLE 23—WEIGHT OF ALUMINUM AND STEEL SHEET

Multiply weight of 3S by 0.996 for weight of 4S
Multiply weight of 3S by 0.985 for weight of 53S

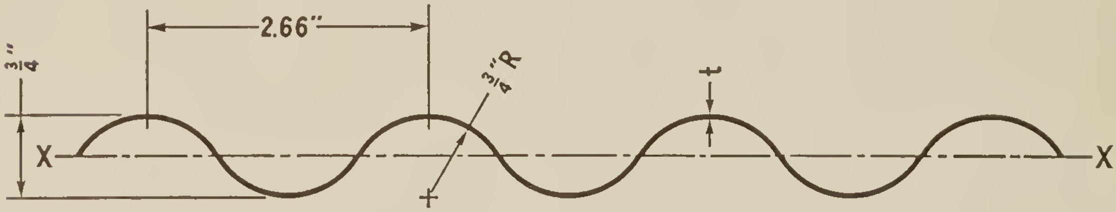
Thickness Inches	B & S Gage	Weight in lb./sq. ft.				U. S. Gage	Thickness Inches
		3S	17S	52S	Steel		
0.2500	..	3.545	3.626	3.467	10.22	3	1/4
0.2344	..	3.323	3.399	3.251	9.57	4	15/64
0.2294	3	3.253	3.327	3.182	....	..	..
0.2188	..	3.102	3.172	3.034	8.95	5	7/32
0.2043	4	2.900	2.966	2.837	....	..	..
0.2031	..	2.880	2.946	2.817	8.30	6	13/64
0.1875	..	2.669	2.730	2.610	7.69	7	3/16
0.1819	5	2.578	2.637	2.522	....	..	..
0.1719	..	2.437	2.493	2.384	7.03	8	11/64
0.1620	6	2.296	2.348	2.246	....	..	..
0.1563	..	2.215	2.266	2.167	6.38	9	5/32
0.1443	7	2.044	2.091	2.000	....	..	..
0.1406	..	2 004	2.050	1.960	5.76	10	9/64
0.1285	8	1.823	1.864	1.783	....	..	..
0.1250	..	1.772	1.813	1.734	5.11	11	1/8
0.1144	9	1.621	1.658	1.586	....	..	..
0.1094	..	1.551	1.586	1.517	4.46	12	7/64
0.1019	10	1.450	1.483	1.418	....	..	..
0.0938	..	1.329	1.360	1.300	3.83	13	3/32
0.0907	11	1.289	1.318	1.261	....	..	..
0.0808	12	1.148	1.174	1.123	....	..	..
0.0781	..	1.108	1.133	1.084	3.19	14	5/64
0.0720	13	1.017	1.040	0.995	....	..	..
0.0703	..	0.997	1.020	0.975	2.87	15	..
0.0641	14	0.909	0.930	0.889	....	..	..
0.0625	..	0.886	0.906	0.867	2.55	16	1/16
0.0571	15	0.810	0.828	0.792	....	..	..
0.0563	..	0.799	0.817	0.781	2.30	17	..
0.0508	16	0.721	0.737	0.705	....	..	..
0.0500	..	0.709	0.725	0.693	2.04	18	..
0.0453	17	0.642	0.657	0.628	....	..	..
0.0438	..	0.621	0.636	0.608	1.79	19	..
0.0403	18	0.572	0.585	0.559	....	..	..
0.0375	..	0.532	0.544	0.520	1.53	20	..
0.0359	19	0.510	0.521	0.498	....	..	..
0.0344	..	0.488	0.500	0.478	1.41	21	..
0.0320	20	0.453	0.464	0.443	....	..	..
0.0313	..	0.444	0.454	0.434	1.28	22	1/32
0.0285	21	0.404	0.413	0.395	....	..	..
0.0281	..	0.399	0.408	0.390	1.15	23	..

13

TABLE 24—CORRUGATED SHEET[1]

Nominal Pitch, 2½ inches

Actual Pitch = 2.66 inches. Depth, d = ¾ inches

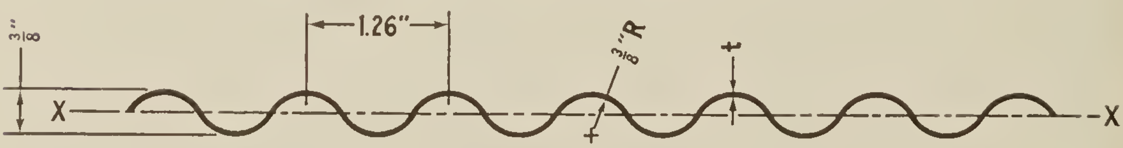


Elements of Section

B & S Gage	Thickness	Weight[2]	12-Inch width of corrugated sheet			
			Area	$I_{x\text{-}x}$	$S_{x\text{-}x}$	$r_{x\text{-}x}$
	Inches	Lb./sq. ft.	In.^{2}	In.^{4}	In.^{3}	Inches
14	0.0641	1.094	0.923	0.0649	0.173	0.266
16	0.0508	0.868	0.732	0.0514	0.137	0.266
18	0.0403	0.669	0.580	0.0408	0.109	0.266
20	0.0320	0.548	0.461	0.0324	0.086	0.266
22	0.0253	0.434	0.364	0.0256	0.068	0.266

Nominal Pitch, 1¼ inches

Actual Pitch = 1.26 inches. Depth, d = ⅜ inches



Elements of Section

B & S Gage	Thickness	Weight[2]	12-Inch width of corrugated sheet			
			Area	$I_{x\text{-}x}$	$S_{x\text{-}x}$	$r_{x\text{-}x}$
	Inches	Lb./sq. ft.	In.^{2}	In.^{4}	In.^{3}	Inches
16	0.0508	0.879	0.744	0.0131	0.0697	0.133
18	0.0403	0.696	0.590	0.0104	0.0553	0.133
20	0.0320	0.553	0.468	0.0082	0.0439	0.133
22	0.0253	0.443	0.370	0.0065	0.0347	0.133
24	0.0201	0.347	0.294	0.0052	0.0276	0.133

[1]A variety of special types and sizes of corrugations and other thicknesses of sheet can be furnished.

[2]Weight given is for 3S alloy. Corrugated sheet can be furnished in other alloys.

TABLE 25—WEIGHTS AND AREAS OF SQUARE AND ROUND BARS

Weights given are for 17S and 27S[1]
For 3S and 4S multiply by 0.978. For 52S and 53S multiply by 0.964

Size	Square		Round	
Inches	Weight, lb./ft.	Area, sq. in.	Weight, lb./ft.	Area, sq. in.
0	0	0	0	0
1/16	0.005	0.0039	0.004	0.0031
1/8	0.019	0.0156	0.015	0.0123
3/16	0.043	0.0352	0.033	0.0276
1/4	0.076	0.0625	0.059	0.0491
5/16	0.118	0.0977	0.093	0.0767
3/8	0.170	0.1406	0.134	0.1104
7/16	0.232	0.1914	0.182	0.1503
1/2	0.303	0.2500	0.238	0.1963
9/16	0.383	0.3164	0.301	0.2485
5/8	0.473	0.3906	0.371	0.3068
11/16	0.572	0.4727	0.449	0.3712
3/4	0.681	0.5625	0.535	0.4418
13/16	0.799	0.6602	0.627	0.5185
7/8	0.926	0.7656	0.728	0.6013
15/16	1.063	0.8789	0.835	0.6903
1	1.210	1.0000	0.950	0.7854
1 1/16	1.366	1.1289	1.073	0.8866
1 1/8	1.531	1.2656	1.203	0.9940
1 3/16	1.706	1.4102	1.340	1.1075
1 1/4	1.891	1.5625	1.485	1.2272
1 5/16	2.084	1.7227	1.637	1.3530
1 3/8	2.288	1.8906	1.797	1.4849
1 7/16	2.500	2.0664	1.964	1.6230
1 1/2	2.723	2.2500	2.138	1.7671
1 9/16	2.954	2.4414	2.320	1.9175
1 5/8	3.195	2.6406	2.509	2.0739
1 11/16	3.446	2.8477	2.706	2.2365
1 3/4	3.706	3.0625	2.910	2.4053
1 13/16	3.975	3.2852	3.122	2.5802
1 7/8	4.254	3.5156	3.341	2.7612
1 15/16	4.542	3.7539	3.567	2.9483
2	4.840	4.0000	3.801	3.1416
2 1/16	5.147	4.2539	4.043	3.3410
2 1/8	5.464	4.5156	4.291	3.5466
2 3/16	5.790	4.7852	4.548	3.7583
2 1/4	6.126	5.0625	4.811	3.9761
2 5/16	6.471	5.3477	5.082	4.2000
2 3/8	6.825	5.6406	5.360	4.4301
2 7/16	7.189	5.9414	5.646	4.6664
2 1/2	7.563	6.2500	5.940	4.9087
2 9/16	7.945	6.5664	6.240	5.1572
2 5/8	8.338	6.8906	6.548	5.4119
2 11/16	8.739	7.2227	6.864	5.6727
2 3/4	9.151	7.5625	7.187	5.9396
2 13/16	9.571	7.9102	7.517	6.2126
2 7/8	10.001	8.2656	7.855	6.4918
2 15/16	10.441	8.6289	8.200	6.7771

[1]Special purpose alloy. See page 19.

14

TABLE 25—WEIGHTS AND AREAS OF SQUARE AND ROUND BARS—Continued

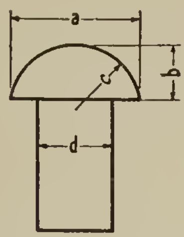
Weights given are for 17S and 27S[1]
For 3S and 4S multiply by 0.978. For 52S and 53S multiply by 0.964

Size	Square		Round	
Inches	Weight, lb./ft.	Area, sq. in.	Weight, lb./ft.	Area, sq. in.
3	10.890	9.0000	8.553	7.0686
3 1/16	11.348	9.3789	8.913	7.3662
3 1/8	11.816	9.7656	9.281	7.6699
3 3/16	12.294	10.1602	9.656	7.9798
3 1/4	12.781	10.5625	10.038	8.2958
3 5/16	13.277	10.9727	10.428	8.6180
3 3/8	13.783	11.3906	10.825	8.9462
3 7/16	14.298	11.8164	11.230	9.2806
3 1/2	14.823	12.2500	11.642	9.6212
3 9/16	15.357	12.6914	12.061	9.9678
3 5/8	15.900	13.1406	12.488	10.3206
3 11/16	16.453	13.5977	12.922	10.6796
3 3/4	17.016	14.0625	13.364	11.0447
3 13/16	17.588	14.5352	13.813	11.4159
3 7/8	18.169	15.0156	14.270	11.7933
3 15/16	18.760	15.5039	14.734	12.1768
4	19.360	16.0000	15.205	12.5664
4 1/16	19.970	16.5039	15.684	12.9622
4 1/8	20.589	17.0156	16.171	13.3641
4 3/16	21.218	17.5352	16.664	13.7721
4 1/4	21.856	18.0625	17.165	14.1863
4 5/16	22.503	18.5977	17.674	14.6066
4 3/8	23.160	19.1408	18.190	15.0330
4 7/16	23.827	19.6914	18.713	15.4656
4 1/2	24.503	20.2500	19.244	15.9044
4 9/16	25.188	20.8164	19.783	16.3492
4 5/8	25.883	21.3906	20.328	16.8002
4 11/16	26.587	21.9727	20.881	17.2574
4 3/4	27.301	22.5625	21.442	17.7206
4 13/16	28.024	23.1602	22.010	18.1900
4 7/8	28.756	23.7656	22.585	18.6655
4 15/16	29.498	24.3789	23.168	19.1472
5	30.250	25.0000	23.758	19.6350
5 1/16	31.011	25.6289	24.356	20.1289
5 1/8	31.781	26.2656	24.961	20.6290
5 3/16	32.561	26.9102	25.574	21.1353
5 1/4	33.351	27.5625	26.194	21.6476
5 5/16	34.149	28.2227	26.821	22.1661
5 3/8	34.958	28.8906	27.456	22.6907
5 7/16	35.775	29.5664	28.098	23.2215
5 1/2	36.603	30.2500	28.748	23.7584
5 9/16	37.439	30.9414	29.405	24.3014
5 5/8	38.285	31.6406	30.069	24.8505
5 11/16	39.141	32.3477	30.741	25.4059
5 3/4	40.006	33.0625	31.420	25.9673
5 13/16	40.880	33.7852	32.107	26.5349
5 7/8	41.764	34.5156	32.801	27.1086
5 15/16	42.657	35.2539	33.503	27.6884

[1]Special purpose alloy. See page 19.

TABLE 26—DIMENSIONS OF STRUCTURAL RIVETS

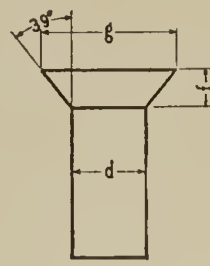
MANUFACTURED HEADS



Button Head

GENERAL
PROPORTIONS

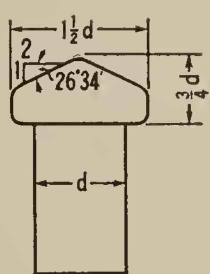
a = 1.75 d
b = 0.75 d
c = 0.885d
f = 0.50 d
g = 1.81 d



Countersunk

ALL VALUES GIVEN IN INCHES

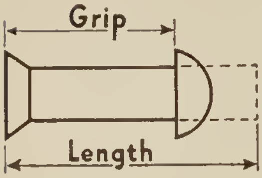
Diameter		¼	5⁄16	⅜	7⁄16	½	⅝	¾	⅞	1	1⅛	1¼
Dimensions	a	0.438	0.547	0.656	0.766	0.875	1.094	1.313	1.531	1.750	1.969	2.188
	b	0.188	0.234	0.281	0.328	0.375	0.469	0.563	0.656	0.750	0.844	0.938
	c	0.221	0.277	0.332	0.387	0.442	0.553	0.664	0.774	0.885	0.995	1.106
	f	0.125	0.156	0.188	0.219	0.250	0.313	0.375	0.438	0.500	0.563	0.625
	g	0.452	0.566	0.679	0.792	0.905	1.131	1.357	1.583	1.810	2.036	2.262



DRIVEN HEAD

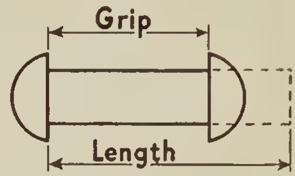
All types of driven heads, including button, steeple, cone, flat, and countersunk, are used for aluminum alloy rivets. The modified cone head shown here is particularly recommended due to the fact that it requires only ⅓ of the driving pressure necessary to form a full button head.

TABLE 27—LENGTH OF RIVETS FOR VARIOUS GRIPS



17S RIVETS IN 17S-T PLATES

BUTTON HEADS



For cone-point heads deduct 1/2 diameter

Hole diameter not more than 1/32 inch greater than rivet diameter

Grip	Diameter of rivet								
	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1
1/8	9/16	5/8	3/4	...	...	...	...	...	...
1/4	3/4	13/16	7/8	15/16	1 1/16	1 5/16	1 9/16	...	...
3/8	15/16	1	1 1/8	1 3/16	1 1/4	1 1/2	1 11/16	1 7/8	2 1/8
1/2	1 1/8	1 3/16	1 1/4	1 5/16	1 7/16	1 11/16	1 13/16	2	2 1/4
5/8	1 1/4	1 5/16	1 3/8	1 7/16	1 9/16	1 13/16	2	2 3/16	2 3/8
3/4	1 7/16	1 1/2	1 9/16	1 5/8	1 11/16	1 15/16	2 3/16	2 5/16	2 1/2
7/8	1 5/8	1 11/16	1 3/4	1 13/16	1 7/8	2 1/16	2 5/16	2 1/2	2 5/8
1	1 13/16	1 13/16	1 7/8	1 15/16	2	2 1/4	2 7/16	2 5/8	2 3/4
1 1/8	...	2	2 1/16	2 1/8	2 3/16	2 3/8	2 5/8	2 3/4	2 15/16
1 1/4	...	2 3/16	2 3/16	2 1/4	2 5/16	2 9/16	2 3/4	2 15/16	3 1/8
1 3/8	...	...	2 3/8	2 7/16	2 1/2	2 11/16	2 7/8	3 1/16	3 5/16
1 1/2	...	...	2 9/16	2 9/16	2 5/8	2 7/8	3 1/16	3 3/16	3 7/16
1 5/8	...	...	...	2 3/4	2 3/4	3	3 3/16	3 3/8	3 9/16
1 3/4	...	...	...	2 15/16	2 15/16	3 1/8	3 3/8	3 1/2	3 3/4
1 7/8	...	...	...	...	3 1/8	3 5/16	3 1/2	3 11/16	3 7/8
2	...	...	...	...	3 5/16	3 7/16	3 11/16	3 13/16	4 1/16
2 1/8	...	...	...	...	...	3 5/8	3 13/16	3 15/16	4 3/16
2 1/4	...	...	...	...	...	3 3/4	4	4 1/8	4 5/16
2 3/8	...	...	...	...	...	3 15/16	4 1/8	4 1/4	4 1/2
2 1/2	...	..	...	...	...	4 1/16	4 1/4	4 7/16	4 5/8

TABLE 28—WEIGHTS OF STRUCTURAL RIVETS

BUTTON HEAD

Weights given are for 17S
For 3S multiply by 0.978. For 53S multiply by 0.964

VALUES GIVEN IN POUNDS PER HUNDRED RIVETS

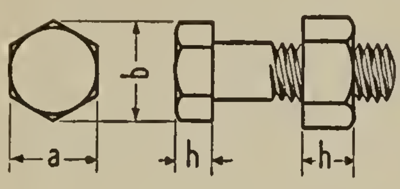
Length under head Inches	Diameter in inches										
	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Weight of → heads only	0.2	0.4	0.6	0.9	1.4	2.8	4.8	7.6	11.3	16.1	22.1
1/2	0.4	...	...	...	...	..	..	..	..	..	..
5/8	0.5	0.9	...	...	...	..	..	..	..	..	..
3/4	0.6	1.0	1.4	...	...	..	..	..	..	..	..
7/8	0.6	1.1	1.6	2.2	...	..	..	..	..	..	..
1	0.7	1.2	1.7	2.4	3.4	..	..	..	..	..	..
1 1/8	0.8	1.3	1.9	2.6	3.6	..	..	..	..	..	..
1 1/4	0.8	1.4	2.0	2.8	3.9	7	..	..	..	..	..
1 3/8	0.9	1.5	2.1	3.0	4.1	7	..	..	..	..	..
1 1/2	0.9	1.6	2.3	3.2	4.4	7	12	..	..	..	..
1 5/8	1.0	1.7	2.4	3.4	4.6	8	12	..	..	..	..
1 3/4	1.1	1.8	2.6	3.6	4.9	8	13	18	..	..	..
1 7/8	1.1	1.9	2.7	3.8	5.1	9	13	19	..	..	..
2	1.2	2.0	2.8	3.9	5.4	9	14	20	27	..	..
2 1/8	1.2	2.0	3.0	4.1	5.6	9	14	21	28	..	..
2 1/4	1.3	2.1	3.1	4.3	5.9	10	15	21	29	39	..
2 3/8	1.4	2.2	3.3	4.5	6.1	10	15	22	30	40	..
2 1/2	1.4	2.3	3.4	4.7	6.4	11	16	23	31	41	53
2 5/8	1.5	2.4	3.5	4.9	6.6	11	17	24	32	42	55
2 3/4	1.6	2.5	3.7	5.1	6.9	11	17	24	33	44	56
2 7/8	1.6	2.6	3.8	5.3	7.1	12	18	25	34	45	58
3	1.7	2.7	3.9	5.5	7.3	12	18	26	35	46	59
3 1/8	1.7	2.8	4.1	5.7	7.6	13	19	27	36	47	61
3 1/4	1.8	2.9	4.2	5.8	7.8	13	19	27	37	49	62
3 3/8	1.9	3.0	4.4	6.0	8.1	13	20	28	38	50	64
3 1/2	1.9	3.1	4.5	6.2	8.3	14	20	29	39	51	65
3 5/8	2.0	3.2	4.6	6.4	8.6	14	21	30	40	52	67
3 3/4	2.0	3.3	4.8	6.6	8.8	14	22	30	41	54	69
3 7/8	2.1	3.4	4.9	6.8	9.1	15	22	31	42	55	70
4	2.2	3.5	5.1	7.0	9.3	15	23	32	43	56	72
4 1/8	2.2	3.6	5.2	7.2	9.6	16	23	33	44	58	73
4 1/4	2.3	3.7	5.3	7.4	9.8	16	24	33	45	59	75
4 3/8	2.4	3.8	5.5	7.6	10.1	16	24	34	46	60	76
4 1/2	2.4	3.9	5.6	7.7	10.3	17	25	35	47	61	78
4 5/8	2.5	4.0	5.8	7.9	10.6	17	25	36	48	63	79
4 3/4	2.5	4.1	5.9	8.1	10.8	18	26	36	49	64	81
4 7/8	2.6	4.2	6.0	8.3	11.1	18	27	37	50	65	82
5	2.7	4.3	6.2	8.5	11.3	18	27	38	51	66	84

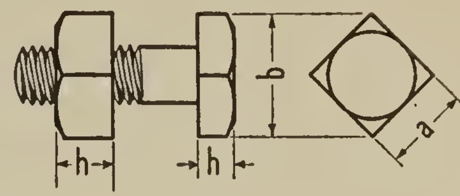
TABLE 29—SHEARING AND BEARING AREAS OF DRIVEN RIVETS

Assuming diameter of driven rivet = 1.05 X nominal diameter of rivet

Nominal rivet diameter in inches		1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Single shear area, sq. in.		0.054	0.085	0.122	0 166	0.216	0.338	0.487	0.663	0.866	1.096	1.353
Bearing areas in square inches for various thicknesses of material.	1/8	0.033	0.041	0.049	0.057	0.066	0.082	0.098	0.115	0.131	0.148	0.164
	3/16	0.049	0.062	0.074	0 086	0.098	0.123	0.148	0.172	0.197	0.221	0.246
	1/4	0.066	0.082	0.098	0.115	0.131	0.164	0.197	0.230	0.263	0.295	0.328
	5/16	0.082	0.103	0.123	0.144	0.164	0.205	0.246	0.287	0.328	0.369	0.410
	3/8	0.098	0.123	0.148	0.172	0.197	0.246	0.295	0.345	0.394	0.443	0.492
	7/16	0.115	0.144	0.172	0.201	0.230	0.287	0.345	0.402	0.459	0.517	0.574
	1/2	0.131	0.164	0.197	0.230	0.263	0.328	0.394	0.459	0.525	0.591	0.656
	9/16	0.148	0.185	0.221	0.258	0.295	0.369	0.443	0.517	0.591	0.664	0.738
	5/8	0.164	0.205	0.246	0.287	0.328	0.410	0.492	0.574	0.656	0.738	0.820
	3/4	0.197	0.246	0.295	0.345	0.394	0.492	0.591	0.689	0.788	0.886	0.984
	7/8	0.230	0.287	0.345	0.402	0.459	0.574	0.689	0.804	0.919	1.034	1.148
	1	0.263	0.328	0.394	0.459	0.525	0.656	0.788	0.919	1.050	1.181	1.313

TABLE 30—DIMENSIONS OF ROUGH AND SEMIFINISHED BOLTS





All dimensions in inches

Diameter of bolt	Threads per inch	Shank			Head					Nut				
		Diameter at root of thread	Gross area in shank	Area at root of thread	Hexagonal		Hex. or square	Square		Hexagonal		Hex. or square	Square	
			Sq. in.	Sq. in.	a	b	h	a	b	a	b	h	a	b
1/4	20	0.1850	0.049	0.027	3/8	0.43	11/64	3/8	0.53	7/16	0.51	7/32	7/16	0.62
5/16	18	0.2403	0.077	0.045	1/2	0.58	13/64	1/2	0.71	9/16	0.55	17/64	9/16	0.80
3/8	16	0.2938	0.111	0.068	9/16	0.65	1/4	9/16	0.80	5/8	0.72	21/64	5/8	0.88
7/16	14	0.3447	0.150	0.093	5/8	0.72	19/64	5/8	0.88	3/4	0.87	3/8	3/4	1.06
1/2	13	0.4001	0.196	0.126	3/4	0.87	21/64	3/4	1.06	13/16	0.94	7/16	13/16	1.15
9/16	12	0.4542	0.249	0.162	7/8	1.01	3/8	7/8	1.24	7/8	1.01	1/2	7/8	1.24
5/8	11	0.5069	0.307	0.202	15/16	1.08	27/64	15/16	1.33	15/16	1.08	35/64	15/16	1.33
3/4	10	0.6201	0.442	0.302	1 1/8	1.30	1/2	1 1/8	1.59	1 1/8	1.30	21/32	1 1/8	1.59
7/8	9	0.7307	0.601	0.419	1 5/16	1.52	19/32	1 5/16	1.86	1 5/16	1.52	49/64	1 5/16	1.86
1	8	0.8376	0.785	0.551	1 1/2	1.73	21/32	1 1/2	2.12	1 1/2	1.73	7/8	1 1/2	2.12
1 1/8	7	0.9394	0.994	0.693	1 11/16	1.95	3/4	1 11/16	2.39	1 11/16	1.95	1	1 11/16	2.39
1 1/4	7	1.0644	1.227	0.890	1 7/8	2.17	27/32	1 7/8	2.65	1 7/8	2.17	1 3/32	1 7/8	2.65

TABLE 31—WEIGHT OF ROUGH AND SEMIFINISHED HEXAGON HEAD BOLTS

Weights in pounds per hundred bolts of alloy 17S

Length under head Inches	Diameter in inches											
	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1 1/8	1 1/4
Weight of heads only →	0.21	0.44	0.69	1.01	1.61	2.50	3.23	5.53	8.92	12.89	18.69	25.90
1/4	0.30	....	....	....	....	....	....	....	.....	.....	.....	.....
1/2	0.40	0.75	1.13	1.62	2.41	3.52	....	....	.....	.....	.....	.....
3/4	0.49	0.90	1.35	1.92	2.81	4.03	5.13	8.31	.....	.....	.....	.....
1	0.61	1.08	1.60	2.26	3.21	4.54	5.77	9.24	14.03	19.57	27.11	.....
1 1/4	0.73	1.27	1.87	2.63	3.70	5.16	6.40	10.17	15.30	21.23	29.21	39.11
1 1/2	0.85	1.46	2.15	3.00	4.19	5.77	7.04	11.10	16.58	22.90	31.31	41.75
1 3/4	0.96	1.63	2.39	3.34	4.67	6.39	7.92	12.19	17.97	24.57	33.41	44.40
2	1.08	1.82	2.66	3.71	5.16	7.00	8.68	13.29	19.47	26.24	35.53	47.05
2 1/4	1.18	1.99	2.94	4.08	5.64	7.61	9.44	14.39	20.85	28.49	37.63	49.70
2 1/2	1.30	2.18	3.21	4.45	6.03	8.23	10.19	15.48	22.35	30.45	39.74	52.31
2 3/4	1.42	2.36	3.48	4.82	6.61	8.84	10.95	16.58	23.85	32.12	42.60	55.00
3	1.54	2.55	3.75	5.19	7.10	9.46	11.71	17.67	25.34	34.08	45.08	57.60
3 1/4	1.66	2.74	3.98	5.50	7.50	9.98	12.35	18.77	26.84	36.04	47.19	61.45
3 1/2	1.78	2.93	4.25	5.87	7.99	10.58	13.11	19.87	28.34	38.01	49.68	64.51
3 3/4	1.90	3.12	4.52	6.24	8.47	11.20	13.86	20.97	29.84	39.96	52.15	67.52
4	2.02	3.31	4.80	6.61	8.95	11.81	14.62	22.08	31.34	41.93	54.64	70.60
4 1/4	2.14	3.49	5.07	6.98	9.44	12.42	15.38	23.01	32.64	43.59	56.74	72.81
4 1/2	2.26	3.68	5.34	7.35	9.93	13.04	16.14	24.11	34.14	45.55	59.22	75.89
4 3/4	2.38	3.87	5.61	7.72	10.41	13.66	16.90	25.21	35.64	47.50	61.69	78.92
5	2.50	4.06	5.88	8.10	10.89	14.26	17.66	26.31	37.14	49.45	64.19	82.00

TABLE 32—WEIGHT OF ROUGH AND SEMIFINISHED HEXAGON NUTS

Weights in pounds per hundred nuts of alloy 17S

Size Inches	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1 1/8	1 1/4
Weight per hundred	0.26	0.53	0.75	1.27	1.65	2.09	3.09	4.33	6.88	10.26	14.85	20.05

TABLE 33—DIMENSIONS AND ELEMENTS OF SECTIONS OF PIPE

Weights given are for 17S

For 3S and 4S multiply by 0.978. For 53S multiply by 0.964

	Size	Diameter		Thickness	Cross-sectional area of wall	Weight	Moment of inertia	Radius of gyration
		Inside	Outside					
	Inches	Inches		Inches	Square inches	Lb. per lin. ft.	In.^{4}	Inches
Standard pipe	1/8	0.269	0.405	0.068	0.0719	0.0870	0.0011	0.124
	1/4	0.364	0.540	0.088	0.1250	0.1513	0.0033	0.163
	3/8	0.493	0.675	0.091	0.1670	0.2021	0.0073	0.209
	1/2	0.622	0.840	0.109	0.2503	0.3029	0.0171	0.261
	3/4	0.824	1.050	0.113	0.3326	0.4024	0.0370	0.334
	1	1.049	1.315	0.133	0.4939	0.5976	0.0874	0.421
	1 1/4	1.380	1.660	0.140	0.6685	0.8089	0.1948	0.540
	1 1/2	1.610	1.900	0.145	0.7995	0.9674	0.3100	0.623
	2	2.067	2.375	0.154	1.0745	1.3001	0.6659	0.787
	2 1/2	2.469	2.875	0.203	1.7040	2.0618	1.5300	0.948
	3	3.068	3.500	0.216	2.2285	2.6965	3.0179	1.164
	3 1/2	3.548	4.000	0.226	2.6795	3.2422	4.7889	1.337
	4	4.026	4.500	0.237	3.1740	3.8405	7.2345	1.510
	4 1/2	4.506	5.000	0.247	3.6882	4.4627	10.4458	1.683
	5	5.047	5.563	0.258	4.2999	5.2029	15.1661	1.878
	6	6.065	6.625	0.280	5.5814	6.7535	28.1494	2.246
	7	7.023	7.625	0.301	6.9257	8.3801	46.5187	2.592
	8	7.981	8.625	0.322	8.3992	10.1630	72.4927	2.938
Extra heavy pipe	1/8	0.215	0.405	0.095	0.0925	0.1119	0.0012	0.114
	1/4	0.302	0.540	0.119	0.1574	0.1905	0.0038	0.155
	3/8	0.423	0.675	0.126	0.2173	0.2629	0.0086	0.199
	1/2	0.546	0.840	0.147	0.3201	0.3873	0.0201	0.251
	3/4	0.742	1.050	0.154	0.4335	0.5245	0.0448	0.321
	1	0.957	1.315	0.179	0.6388	0.7729	0.1056	0.407
	1 1/4	1.278	1.660	0.191	0.8815	1.0666	0.2419	0.524
	1 1/2	1.500	1.900	0.200	1.0681	1.2924	0.3913	0.605
	2	1.939	2.375	0.218	1.4773	1.7875	0.8681	0.767
	2 1/2	2.323	2.875	0.276	2.2535	2.7267	1.9247	0.924
	3	2.900	3.500	0.300	3.0159	3.6492	3.8953	1.137
	3 1/2	3.364	4.000	0.318	3.6784	4.4509	6.2817	1.307
	4	3.826	4.500	0.337	4.4074	5.3330	9.6130	1.477
	4 1/2	4.290	5.000	0.355	5.1804	6.2683	14.0568	1.647
	5	4.813	5.563	0.375	6.1120	7.3955	20.6760	1.839
	6	5.761	6.625	0.432	8.4050	10.1701	40.5011	2.195
	7	6.625	7.625	0.500	11.1920	13.5423	71.3741	2.525
	8	7.625	8.625	0.500	12.7628	15.4430	105.7218	2.878

SPECIFICATIONS, TOLERANCES, AND COMMERCIAL SIZES OF STRUCTURAL MATERIAL

TABLE 34—SPECIFICATIONS FOR ALUMINUM ALLOYS USED FOR STRUCTURAL MATERIAL

Wrought alloys		Federal[1]	Army[1]	Navy[1]	S.A.E.	A.S.T.M.
3S	Sheet and plate	QQ-A-359	Federal	47A4	29	B79-36T
	Bar, rod, wire, and shapes	QQ-A-356	Federal	46A6	29	....
	Tubing	WW-T-788	Federal	44T20	29	....
	Tread plate	....	......	47A7	29	....
	Rivets and rivet wire and rod	....	......	43R5	29	....
4S	Sheet and plate	....	......	.....	20	....
	Bar, rod, wire, and shapes	....	......	.....	20	....
	Tubing	....	11069	.....	20	....
14S	Forgings	QQ-A-367	57-153	.....	..	....
17S	Sheet and plate	QQ-A-353	Federal	47A3	26	B78-36T
	Bar, rod, wire, and shapes	QQ-A-351	Federal	46A4	26	B89-36T
	Tubing, round	WW-T-786	Federal	44T21	26	....
	Tubing, streamline	....	57-187-2	44T22	26	....
	Forgings	QQ-A-367	57-153	46A7	26	....
	Rivets and rivet wire and rod	....	25526	43R5	26	....
	Bolts and nuts	....	29-59	.....	26	....
	Bolts, nuts, studs, and tap rivets	FF-B-571	......	43B11	26	....
	Machine screws	FF-S-91	Federal	42S5	..	....
27S[2]	Forgings	QQ-A-367	57-153	.....	..	....
A51S	Forgings	QQ-A-367	57-153	46A7	..	....
52S	Sheet and plate	....	11072	47A11	..	B109-36T
	Tubing	....	57-187-3	44T32	..	....
	Bar, rod, and wire	....	......	46A11	..	....
53S	Sheet and plate	QQ-A-334	......	47A12	..	....
	Bar, rod, wire, and shapes	QQ-A-331	......	46A10	..	....
	Tubing	....	......	44T30	..	....
	Rivets	....	......	43R5	..	....
Sand castings						
43		....	57-72	46A1-Class 2	35	B26-36T
195		....	57-72-5A 57-72	46A1-Class 4	38	B26-36T
214		....	57-72-4	46A1-Class 5	320	B26-36T
220		....	11309-A	.....	324	....
356		....	11308-A	46A1-Class 3	323	B26-36T

[1]Revisions of Federal, Army, and Navy specifications are designated by a letter following the specification number. Purchasers should specify that material conform with the issue of the specifications in effect at the date of the proposal under which the contract was issued.
[2]Special purpose alloy. See page 19.

TABLE 35—MECHANICAL PROPERTIES SPECIFICATIONS FOR SHEET AND PLATE 3S, 4S, AND 52S

Sheet

Alloy	Tensile Strength Lb./sq. in. Minimum except for soft temper (O)	Minimum elongation[1]—per cent in 2 inches								
		.250″–.204″	5–6 Gage .203″–.162″	7–9 Gage .161″–.114″	10–16 Gage .113″–.051″	17–20 Gage .050″–.032″	21–24 Gage .031″–.020″	25–28 Gage .019″–.013″	29–32 Gage .012″–.008″	33–36 Gage .007″–.005″
3S-O	19,000[2]	25	25	25	25	23	20	20	18	16
3S-¼H	17,000	9	9	8	7	6	5	4	..	..
3S-½H	19,500	8	8	7	6	5	4	3	2	..
3S-¾H	23,500	..	..	4	4	3	2	1	1	1
3S-H	27,000	..	..	4	4	3	2	1	1	1
4S-O	29,000[2]	18	18	18	18	16	14	10	..	..
4S-¼H	28,000	7	7	7	6	5	4	2	..	..
4S-½H	32,000	6	6	6	5	4	4	2	..	..
4S-¾H	35,000	..	..	4	4	4	2	2	..	..
4S-H	38,000	..	..	4	4	3	2	2	..	..
52S-O	31,000[2]	20	20	20	20	20	18	15	..	..
52S-¼H	31,000	10	10	10	8	6	6	5	..	..
52S-½H	34,000	8	8	8	7	5	5	4	..	..
52S-¾H	37,000	..	..	4	4	4	3	3	..	..
52S-H	39,000	..	..	4	4	4	3	3	..	..

Plate

3S, 4S, and 52S, As Rolled—No physical tests required.

O, ¼H, ½H { Physical properties same as for ¼-inch sheet in same alloy and temper. (See Tables 49 and 50 for temper available in various thicknesses.)

MAXIMUM AND MINIMUM COMMERCIAL THICKNESS OF FLAT SHEET IN ALL TEMPERS

Temper	Flat sheet — Thickness in inches	
	Maximum	Minimum
0	0.250	0.010
¼H	0.250	0.016
½H	0.250	0.010
¾H	0.162	0.010
H	0.128	0.010

[1]Test specimens taken parallel to direction of rolling from flat sheet in ¼H and ½H tempers.
[2]Maximum. So specified to insure complete annealing.

TABLE 36—MECHANICAL PROPERTIES SPECIFICATIONS FOR 17S ALLOY PRODUCTS[1]

Material	Dimensions[1] Inches	Tensile Strength Lb./sq. in. Minimum except for 17S-O[2]	Yield Strength[1] (Set = 0.2%) Lb./sq. in. Minimum	Elongation Per Cent in 2 inches or in 4D[1] Minimum
Sheet and Plate				
17S-O	0.010—0.500	35,000[2]	......	12
17S-T	0.010—0.020	55,000	32,000	15
	0.021—0.040	55,000	32,000	17[3]
	0.041—0.128	55,000	32,000	18
	0.129—0.258	55,000	32,000	15
	0.259—0.500	55,000	32,000	12
	0.501—1.000	55,000	32,000	10
	1.001—1.500	55,000	32,000	9
	1.501—2.000	53,000	32,000	8
	2.001—3.000	50,000	32,000	6
Rod, Bar, and Shapes				
17S-O Bar, rod, shapes	0.125—8.000	35,000[2]	......	12
17S-T Rounds, squares, hexagons, octagons (rolled)	0.125—0.750	55,000	30,000	18
	0.751—3.000	53,000	30,000	18
	3.001—8.000	50,000	30,000	16
17S-T Rectangular bars	up to 0.750	53,000	30,000	16
	0.751—3.000	50,000	30,000	16
17S-T Structural shapes (rolled)	....	50,000	30,000	16
17S-T Extruded shapes	....	50,000	35,000	12
Tubing				
17S-O	All	35,000[2]	......	..
17S-T	¼—1 incl.	55,000	40,000	16
	over 1—1½ incl.	55,000	40,000	14
	over 1½—9 incl.	55,000	40,000	12
Forgings				
17S-T	up to 4	55,000	30,000	16

[1]See page 20 for definitions and significance of terms; also additional data.

[2]Maximum. So specified to insure complete annealing.

[3]For sheets less than 30 inches wide, elongation shall be 18% in 2 inches.

TABLE 37—MECHANICAL PROPERTIES SPECIFICATIONS FOR 27S[1] ALLOY PRODUCTS[2]

Material	Dimensions[2] Inches	Tensile Strength Lb./sq. in. Minimum	Yield Strength[2] (Set = 0.2%) Lb./sq. in. Minimum	Elongation Per Cent in 2 inches or in 4D[2] Minimum
Sheet and Plate				
27S-T[1]	0.125—0.499	60,000	45,000	7
	0.500—0.750	58,000	45,000	8
	0.751—2.000	54,000	40,000	8
Rod, Bar, and Shapes				
27S-T[1] Rounds, squares, and hexagons	up to 1.500	58,000	45,000	9
	1.501 to 3.000	54,000	40,000	8
27S-T[1] Rectangular bars	up to 1.500	58,000	45,000	9
	1.501 to 3.000	54,000	40,000	8
27S-T[1] Structural shapes (rolled)	....	58,000	45,000	9
27S-T[1] Extruded shapes	....	56,000	45,000	8

[1]Special purpose alloy. See page 19.
[2]See page 20 for definitions and significance of terms; also additional data.

TABLE 38—MECHANICAL PROPERTIES SPECIFICATIONS FOR 53S ALLOY PRODUCTS[1]

Material	Dimensions[1] Inches	Tensile Strength Lb./sq. in. Minimum except for 53S-O[2]	Yield Strength[1] (Set = 0.2%) Lb./sq. in. Minimum	Elongation Per Cent in 2 inches or in 4D[1] Minimum
Sheet and Plate				
53S-O	0.010—0.032	19,000[2]	......	20
	0.033—0.128	19,000[2]	......	22
	0.129—0.500	19,000[2]	......	25
53S-W	0.010—0.032	28,000	16,000	12
	0.033—0.050	28,000	16,000	15
	0.051—0.258	28,000	16,000	20
	0.259—0.500	28,000	16,000	18
53S-T	0.010—0.031	35,000	28,000	8
	0.032—0.500	35,000	28,000	10
Rod, Bar, and Shapes				
53S-O (rolled)	0.125—3.000	19,000[2]	......	20
53S-O (extruded)	....	19,000[2]	......	18
53S-W—Rounds, squares, hexagons, octagons, rectangles (rolled)	0.125—3.000	25,000	14,000	20
53S-W—Shapes (rolled or extruded)	....	25,000	14,000	18
53S-T—Rounds, squares, hexagons, octagons (rolled)	0.125—3.000	32,000	25,000	14
53S-T—Rectangles (rolled)	up to 0.750	32,000	25,000	14
	0.751—3.000	32,000	25,000	14
53S-T—Shapes (extruded or rolled)	....	32,000	25,000	10
Tubing				
53S-O	All	19,000[2]	......	..
53S-W	¼—1 incl.	28,000	14,000	18
	over 1—1½ incl.	28,000	14,000	20
	over 1½—8 incl.	28,000	14,000	18
53S-T	¼—1 incl.	35,000	28,000	16
	over 1—1½ incl.	35,000	28,000	14
	over 1½—8 incl.	35,000	28,000	12
Forgings				
53S-T	up to 4 inches	36,000	30,000	16

[1]See page 20 for definitions and significance of terms; also additional data.
[2]Maximum. So specified to insure complete annealing.

TABLE 39—MECHANICAL PROPERTIES OF ALUMINUM ALLOY FORGINGS[1]

Alloy	Minimum Specification Values				Typical Values (not guaranteed)		
	Tension[2]			Hardness	Shear	Fatigue	Weight
	Yield strength[1] (Set = 0.2%) Lb./sq. in.	Ultimate strength Lb./sq. in.	Elongation[1] Per Cent in 2 inches	Brinell[2] 500 Kg. load 10 mm. ball	Shearing strength[1] Lb./sq. in.	Endurance limit[1] Lb./sq. in.	Lb./cu. in.
14S-T	50,000	65,000	10.0	130	45,000	16,000	0.101
17S-T	30,000	55,000	16.0	100	36,000	15,000	0.101
A51S-T	34,000	44,000	14.0	90	32,000	10,500	0.097
53S-T	30,000	36,000	16.0	75	24,000	11,000	0.097

[1]These properties apply to forgings up to 4 inches in diameter or thickness. Long axis of test specimen taken parallel to direction of grain flow. See page 20 for definitions and significance of terms; also additional data.

[2]Tension and hardness values determined from standard half-inch diameter test specimens. Values in compression at least equal to values in tension.

TABLE 40—COMMERCIAL TOLERANCES FOR SHEET AND PLATE ALL ALLOYS

Width, Length, Diameter

FLAT SHEET—SHEARED

Width Tolerance (Plus or Minus), Inches

Thickness B & S gage	Thickness Inches	Width ¼″ to 4″ incl.	Width over 4″ to 18″ incl.	Width over 18″ to 36″ incl.	Width over 36″ to 54″ incl.	Width over 54″ to 72″ incl.	Width over 72″ to 102″ incl.
3–9	0.249 to 0.103	..	3/32 [2]	1/8	3/16	3/16	1/4
10–35	0.102 to 0.0056	1/32 [1]	1/16	3/32	1/8	5/32	3/16

Length Tolerance (Plus or Minus), Inches

Thickness	Length up to 18″ incl.	Length over 18″ to 48″ incl.	Length over 48″ to 120″ incl.	Length over 120″ to 180″ incl.	Length over 180″ to 540″ incl.
All gages	1/16	3/32	1/8	5/32	1/4

SHEET AND PLATE—SAWED

Dimension Tolerance (Plus or Minus), Inches

Thickness Inches	Dimensions up to 10″ incl.	Dimensions over 10″ to 36″ incl.	Dimensions over 36″ to 60″ incl.	Dimensions over 60″ to 130″ incl.
Up to 3	1/32	1/16	3/32	3/32

PLATE—SHEARED

Width and Length Tolerance (Plus only), Inches

Thickness[3] Inches	Width tolerance[3]	Length tolerance: Length up to 12 feet	Length tolerance: Length over 12 feet to 20 feet	Length tolerance: Length over 20 feet to 45 feet
1.000 to 0.501	1/2	1/2	9/16	5/8
0.500 to 0.250	3/8	3/8	7/16	1/2

[1]For widths of 4 inches or less, the maximum thickness of flat sheet which can be sheared is 0.092 inches. Thicker sheet must be sawed.

[2]For flat sheet in thicknesses of 0.201 inches to 0.249 inches the minimum width which can be sheared is 5 inches. Narrower widths must be sawed.

[3]For limits for shearing plate see Tables 50 and 51.

18

TABLE 40—COMMERCIAL TOLERANCES FOR SHEET AND PLATE ALL ALLOYS—Continued

Thickness Tolerances

FLAT SHEET—ALL ALLOYS EXCEPT 52S

Thickness		Tolerance (Plus or Minus) in inches except where shown as per cent of nominal thickness, t					
B & S gage	Inches	Width up to 18″ incl.	Width over 18″ to 36″ incl.	Width over 36″ to 54″ incl.	Width over 54″ to 72″ incl.	Width over 72″ to 90″ incl.	Width over 90″ to 102″ incl.
3–8	0.249 to 0.129	4%t	4%t	5%t	6%t	7%t	8%t
9–10	0.128 to 0.092	0.004	0.0045	0.005	0.007	0.009	0.010
11–12	0.091 to 0.073	0.003	0.003	0.004	0.006	0.008	.....
13–16	0.072 to 0.051	0.0025	0.003	0.004	0.005	0.007	.....
17–18	0.050 to 0.037	0.002	0.0025	0.003	0.004	.....	.....
19–25	0.036 to 0.018	0.0015	0.002	0.0025	.....	.....	.....
26–30	0.017 to 0.010	0.0015	0.0015	0.002	.....	.....	.....

PLATE—ALL ALLOYS

Thickness Inches	Tolerance (Plus or Minus) in per cent of nominal thickness			
	Width up to 54″ incl.	Width over 54″ to 72″ incl.	Width over 72″ to 90″ incl.	Width over 90″ to 120″ incl.
3.000 to 1.001	3	3	4	5
1.000 to 0.501	4	4	5	6
0.500 to 0.375	5	5	6	7
0.374 to 0.250	5	6	7	8

FLAT SHEET—52S

Thickness		Tolerance (Plus or Minus) in inches except where shown as per cent of nominal thickness, t							
B & S gage	Inches	Width up to 36″ incl.	Width over 36″ to 42″ incl.	Width over 42″ to 48″ incl.	Width over 48″ to 54″ incl.	Width over 54″ to 60″ incl.	Width over 60″ to 66″ incl.	Width over 66″ to 72″ incl.	Width over 72″ to 84″ incl.
3–8	0.249 to 0.126	4% t	5% t	5% t	5% t	6% t	8% t	10% t	11% t
9–10	0.125 to 0.092	0.0045	0.005	0.005	0.005	0.007	0.010	0.012	.....
11–12	0.091 to 0.077	0.003	0.004	0.004	0.004	0.006	0.008	0.010	.....
13–16	0.076 to 0.051	0.003	0.004	0.004	0.004	0.005	.....	.....	.....
17–18	0.050 to 0.037	0.0025	0.003	0.003	0.003	0.004	.....	.....	.....
19–20	0.036 to 0.030	0.0025	0.003	0.003	.....	.....	.....	.....	.....
21–22	0.029 to 0.025	0.0025	0.003	.....	.....	.....	.....	.....	.....
23–24	0.024 to 0.019	0.002	0.003	.....	.....	.....	.....	.....	.....
25–26	0.018 to 0.016	0.002	.....	.....	.....	.....	.....	.....	.....
27–30	0.015 to 0.010[1]	0.0015	.....	.....	.....	.....	.....	.....	.....

[1]Maximum width 0.013 inch and thinner = 30 inches.

TABLE 41—COMMERCIAL TOLERANCES FOR EXTRUDED PRODUCTS

SHAPES

Cross-Sectional Tolerances (Plus or Minus), Inches

Dimensions in inches	3S and 4S 17S and 53S not heat treated	17S and 53S heat treated
0.000 to 0.125	0.007	0.010
0.126 to 0.500	0.010	0.015
0.501 to 1.000	0.015	0.020
1.001 to 2.000	0.017	0.025
2.001 to 3.000	0.020	0.030
3.001 to 4.000	0.025	0.035
4.001 to 5.000	0.030	0.040
5.001 to 6.000	0.035	0.045
6.001 to 7.000	0.040	0.050
7.001 to 8.000	0.045	0.055
8.001 to 9.000	0.050	0.060
9.001 to 10.000	0.055	0.065
10.001 to 11.000	0.060	0.070
11.001 to 12.000	0.065	0.080

ROUND, SQUARE, RECTANGULAR, AND HEXAGON

Dimensions in inches	All grades—as extruded or heat treated Inches
Up to 0.500	0.007
0.501 to 1.000	0.010
1.001 to 2.000	0.012
2.001 to 3.000	0.015
3.001 and over	0.018

EXTRUDED AND DRAWN ROD

Dimensions in inches	All grades—as extruded or heat treated Inches
0.375 to 0.500	0.0015
0.501 to 1.000	0.002
1.001 to 2.500	0.0025

Length Tolerances

Length in feet	Tolerance in inches
Up to 13	$-0, +\frac{1}{8}$
Over 13	$-0, +\frac{1}{4}$

Standard Structural Shapes, rolled or extruded (Channels, I-beams, Angles, Z's, and T's), in which the thickness of web, flange, or leg is not less than 0.140 inches are manufactured to a tolerance of $2\frac{1}{2}$ per cent (plus or minus) on the nominal weight of the section. Actual weight shipped is invoiced.

TABLE 42—COMMERCIAL TOLERANCES FOR TUBING

ROUND TUBING

Diameter Tolerance

Nominal diameter Inches	Tolerance in inches (Plus or Minus)		
	Mean diameter[1] or pi-tape measurement—3S, 17S, and 53S	Individual measurement of diameter (out-of-roundness)	
		3S except soft temper (O) or thin wall[2] tubes	17S and 53S
⅜ to ½ incl.	0.003	0.003	0.006
Greater than ½ to 1 incl.	0.004	0.004	0.008
Greater than 1 to 2 incl.	0.005	0.005	0.010
Greater than 2 to 3 incl.	0.006	0.006	0.012
Greater than 3 to 5 incl.	0.008	0.008	0.016
Greater than 5 to 6 incl.	0.010	0.010	0.020
Greater than 6 to 8 incl.	0.015	0.015	0.030
Greater than 8 to 10 incl.	0.020	0.020	0.040
Greater than 10 to 12 incl.	0.025	0.025	0.050

[1]Mean diameter is the average of any two measurements of diameter taken at right angles to each other at any point along the length of the tube.

[2]Thin wall tubes and tubes in the soft temper (O) shall be commercially round. The deviations of individual measurements from the nominal will vary with the alloy and the ratio of wall thickness to diameter.

Wall Thickness Tolerance

Nominal wall thickness Inches	Tolerance in inches (Plus or Minus)		
	Mean wall thickness[3]	Individual measurements of wall thickness	
	17S, 53S	17S, 53S	3S
0.010 to 0.035	0.002	10% of w. t.[4]	0.002
0.036 to 0.049	0.003	10% of w. t.[4]	0.003
0.050 to 0.120	0.004	10% of w. t.[4]	0.004
0.121 to 0.203	0.005	10% of w. t.[4]	0.005
0.204 to 0.300	0.008	10% of w. t.[4]	0.008
0.301 to 0.375	0.012	10% of w. t.[4]	0.012
0.376 to 0.500	0.032	10% of w. t.[4]	0.032

[3]Mean wall thickness is the average of the two measurements taken at opposite ends of any diameter of the tube.

[4]Wall thickness.

TABLE 42—COMMERCIAL TOLERANCES FOR TUBING—Continued

ROUND TUBING

Length Tolerances—All Alloys

Nominal diameter Inches	Plus tolerance in inches				Plus
	Lengths 2′ or less	Lengths over 2′ to 20′ incl.	Lengths over 20′ to 30′ incl.	Lengths over 30′	Coiled tubing
To 1/4″ incl.	1/8	1/4	3/8	1/2	3%
Over 1/4″ to 2″ incl.	1/16	1/8	3/16	3/8	2%
Over 2″ to 3″ incl.	1/8	3/16	1/4	5/16	...
Over 3″ to 10″ incl.	3/16	1/4	5/16	3/8	...
Over 10″ to 12″ incl.	1/4	5/16	3/8	..	...

A tolerance of 1/64 inch per inch of O.D., or fraction thereof, will apply on the squareness of all saw cuts.

Straightness Tolerance—All alloys, all tempers except soft[1]

Outside diameters[1] in inches	Tolerance
3/8 to 12	One part in 1200 parts of length, e.g., 0.1 inch in 10 feet

[1]Tubing in the soft temper or in diameters less than 3/8 inch is supplied commercially straight.

PIPE—STANDARD AND EXTRA HEAVY I. P. S.—3S

Size in inches	O. D. tolerance Inches	I. D. tolerance Inches	Straightness	Length
1/8 to 1/2 incl.	+0.005, −0	+0, −0.003	Same as on commercial round tubing	Same as on commercial round tubing
Greater than 1/2 to 2 incl.	+0.008, −0	+0, −0.005		
Greater than 2 to 4 incl.	+0.010, −0	+0, −0.007		
Greater than 4 to 6 incl.	+0.012, −0	+0, −0.008		
Greater than 6 to 8 incl.	+0.014, −0	+0, −0.009		
Greater than 8 to 10 incl.	+0.016, −0	+0, −0.012		

TABLE 43—COMMERCIAL TOLERANCES OF ROLLED STRUCTURAL SHAPES

Dimensions	Tolerance
Thickness of section	Plus or minus 2½% of nominal thickness. Minimum tolerance = ±0.010 inch.
Overall dimensions. Length of leg of angles or zees.	Plus or minus 2½% of nominal dimensions. Minimum tolerance = ±1/16 inch.
Length	
Up to 20 feet, not inclusive.	Minus 0, plus ¼ inch.
20 feet to 30 feet, inclusive.	Minus 0, plus ⅜ inch.
Over 30 feet.	Minus 0, plus ½ inch.
Channels, overall width.	Plus 3/32 inch, minus 1/16 inch.
Channels, width of flange.	Plus or minus 4% of nominal width.
Weight of a lot or shipment of sizes 3 inches or larger.	Plus or minus 2½% of nominal weight.[1]

[1]Actual weight shipped is invoiced. For sizes smaller than 3 inches, dimension tolerances only apply.

TABLE 44—COMMERCIAL TOLERANCES FOR ROD AND BAR—ALL ALLOYS

ROLLED ROD ROUND (ALL ALLOYS)

Diameter Inches	Tolerance in inches		Diameter Inches	Tolerance in inches	
	Plus	Minus		Plus	Minus
1.501 to 3.499	0.008	0.008	5.001 to 8.000	1/16	1/32
3.500 to 5.000	1/32	1/64	....	..	..

ROLLED BAR (ALL ALLOYS)

(Squares, Hexagons[1], Octagons[1], and Rectangles)

Least distance across flats, Inches	Tolerance in inches (Plus or minus)	Width of rectangles Inches	Tolerance in inches (Plus or minus)
Up to 0.500	0.006	Up to 1.500	1/64
0.501 to 0.750	0.008	1.501 to 4.000	1/32
0.751 to 1.000	0.012	4.001 to 6.000	3/64
1.001 to 2.000	0.016	6.001 to 10.000	1/16
2.001 to 3.000	0.020	....	..

COLD FINISHED ROD AND BAR (ALL ALLOYS)

(Rounds, Squares, Hexagons, and Octagons)

Rectangles up to 3.00 inches wide (provided area is not greater than 3 square inches)

Diameter or Distance across flats Inches	Tolerance in inches (Plus or minus)		
	Rounds	Square Hexagons Octagons	Rectangles
Up to 0.0359	0.0005	......	......
0.036 to 0.064	0.001	0.0015	0.0015
0.065 to 0.500	0.0015	0.002	0.002
0.501 to 1.000	0.002	0.0025	0.0025
1.001 to 1.500	0.0025	0.003	0.003
1.501 to 3.000	......	.....	0.005

COLD FINISHED RECTANGLES[2] 3S, 52S, AND 53S

Thickness Inches	Tolerance in inches (Plus or minus)	Width Inches	Tolerance in inches (Plus or minus)
Up to 0.250	0.0025	2.000 to 4.000	1/32
0.251 to 0.500	0.0035	....	..
0.501 to 0.750	0.005	....	..
0.751 to 1.500	0.008	....	..

[1]Available in sizes greater than 1.5 inches; smaller sizes cold finished.
[2]Widths greater than 3.00 inches and/or area greater than 3 square inches. Maximum dimensions 1.5 inches by 4 inches.

TABLE 45—MAXIMUM COMMERCIAL SIZES OF FLAT SHEET[1]
3S ALLOY

Thickness Inches	Rolling Limits		Stretcher Limits	
	Width Inches	Length Feet	Width Inches	Length Feet
0.249-0.172	102	30	90	**
0.171-0.136	102	30	90	**
0.135-0.096	102	30	88	**
0.095-0.068	90	30	86	**
0.067-0.043	84 76 60	16 20 30	76	20
0.042-0.038	76 66 60	16 20 30	**	20
0.037-0.030	66 60	14 20	**	**
0.029-0.019	60 54	10 16	**	**
0.018-0.015	48	12	**	**
0.014-0.012	42	12	**	**
0.011-0.0095	36	12	**	**
0.009-0.0056	30	8	**	**

[1]Available in tempers O to H with the following limitations: maximum thickness for H temper 0.128 inch; for ¾H 0.162 inch. Minimum thickness for ¼H temper 0.016 inch.
**Greater than rolling limits.

TABLE 46—MAXIMUM COMMERCIAL SIZES OF FLAT SHEET[1] 4S AND 52S ALLOYS

Thickness Inches	Rolling limits 4S		Rolling limits 52S		Stretcher limits[3] 4S and 52S
	Width[2] Inches	Length Feet	Width[2] Inches	Length Feet	
0.249–0.172	102	24	84	24	90″ x **
0.171–0.136	102	24	72	24	90″ x **
0.135–0.096	90	24	72	24	88″ x **
0.095–0.086	84	24	72	24	**
0.085–0.077	72	24	72	24	**
0.076–0.054	60	20	60	20	**
0.053–0.038	60	14	60	14	**
0.037–0.030	48	14	48	14	**
0.029–0.024	42	12	42	12	**
0.023–0.019	42	10	42	10	**
0.018–0.015	36	10	36	10	**
0.014–0.010	30	8	30	8	**

[1]Available in tempers O to H with the following limitations: maximum thickness for H temper 0.128 inch, for ¾H 0.162 inch. Minimum thickness for ¼H temper 0.016 inch.

[2]Maximum width of sheet in the hard temper (H) is 54 inches and in the three-quarter hard temper (¾H) is 60 inches.

[3]Sheet harder than ½H cannot be stretcher leveled.

**Greater than rolling limits.

TABLE 47—MAXIMUM COMMERCIAL SIZES OF STRONG ALLOY FLAT SHEET[4] 17S AND 53S—O, W, AND T TEMPER

Thickness Inches	Width Inches	Length Feet	Diameter of circle Inches	Stretcher Maximum
0.249 to 0.136	102	24	96	90″ x **
0.135 to 0.096	102	24	96	88″ x **
0.095 to 0.068	90	24	90	86″ x **
0.067 to 0.061	84	24	84	**
0.060 to 0.048	72	18	72	**
0.047 to 0.038	60	18	60	**
0.037 to 0.030	48	18	48	**
0.029 to 0.019	42	16	42	**
0.018 to 0.015	36	14	36	**
0.014 to 0.010	28	14	28	**

[4]Maximum size of annealed sheet 118″ x 30′.

**Greater than rolling limits.

19

TABLE 48—MAXIMUM COMMERCIAL SIZES OF ALCOA TREAD PLATE[1]—4S, 17S, AND 53S ALLOYS

Thickness Inches	Maximum size		Approximate weight/sq. ft. Pounds
	Width Inches	Length Feet	
1/8	50	24	2.0
3/16	60	24	2.8
1/4	60	24	3.7
5/16	60	24	4.6
3/8	60	24	5.5

[1]Supplied in the following tempers:
(a) 4S—As Rolled.
(b) 17S-O and 17S-T.
(c) 53S—As Rolled, 53S-O, 53S-W, and 53S-T.

TABLE 49—MAXIMUM COMMERCIAL[2] SIZES OF PLATE[3] 3S ALLOY

Thickness Inches	Maximum width Inches	Maximum length for maximum width, Feet	Maximum length in feet for indicated widths							
			Widths 40 inches or less	Width 60 inches	Width 72 inches	Width 84 inches	Width 96 inches	Width 108 inches	Width 120 inches	Width 132 inches
3	92	7.6	17.7	11.8	9.9	8.4	....	....	....	....
2¾	96	8.0	19.3	12.8	10.6	9.1	8.0	....	....	....
2½	101	8.4	21.2	14.2	11.7	10.0	8.7	....	....	....
2¼	106	8.8	22.8	15.2	12.6	10.8	9.5	....	....	....
2	113	9.4	26.5	17.6	14.6	12.5	10.8	9.7	....	....
1¾	120	10.0	30.3	20.1	16.7	14.3	12.5	11.1	10.0	....
1½	130	10.8	35.4	23.6	19.6	16.8	14.7	13.0	11.7	....
1¼	132	12.9	42.5	28.3	23.6	20.2	17.6	15.6	14.0	12.9
1	132	16.2	53.1	35.4	28.5	24.4	21.3	18.9	17.0	16.2
7/8	132	18.5	60.8	40.5	33.7	28.8	25.2	22.4	20.1	18.5
3/4	132	21.6	70.7	47.0	39.2	33.6	29.4	26.1	23.4	21.6
5/8	132	25.8	72.0	56.7	47.3	40.5	35.4	31.4	28.2	25.8
1/2	132	32.2	60.0	60.0	59.0	50.5	44.0	39.1	35.1	32.2
3/8	120	41.8	40.0	60.0	72.0	67.2	58.8	52.1	41.8	....
1/4	102	48.0	36.0	50.0	60.0	60.0	60.0	....	....	....

[2]Same as in Table 50.
[3]Same as in Table 50, except that Note [2] (b) does not apply to this table.

TABLE 50—MAXIMUM COMMERCIAL[1] SIZES OF PLATE[2] 4S AND 52S ALLOYS

Thickness Inches	Maximum width Inches	Maximum length for maximum width		Maximum length in feet for indicated widths						
		Inches	Feet	Widths 43 inches or less	Width 60 inches	Width 72 inches	Width 84 inches	Width 96 inches	Width 108 inches	Width 120 inches
3	82	82	6.8	12.9	9.1	7.6	....	....	....	....
2¾	85	85	7.1	14.0	10.0	8.3	....	....	....	....
2½	87	87	7.2	15.4	11.0	9.1	....	....	....	....
2¼	94	94	7.8	17.1	12.2	10.1	8.5	....	....	....
2	100	100	8.3	19.3	13.8	11.5	9.7	....	....	....
1¾	107	107	8.9	22.1	15.7	13.0	11.1	9.7	....	....
1½	116	116	9.7	25.8	18.3	15.2	12.8	11.4	10.2	....
1¼	120	130	10.8	30.9	22.0	18.3	15.6	13.6	12.0	10.8
1	120	166	13.8	38.6	27.6	23.0	19.7	17.2	15.2	13.8
⅞	120	190	15.8	44.1	31.5	26.2	22.4	19.6	17.4	15.8
¾	120	222	18.5	51.5	36.8	30.6	26.2	22.8	20.2	18.5
⅝	120	266	22.2	60.0	44.2	36.8	30.5	26.6	23.6	22.2
½	120	332	27.7	60.0	55.0	45.7	39.0	34.0	30.2	27.8
⅜	96	555	46.2	40.0	50.0	61.3	52.5	46.2	....	....
¼	90	600	50.0	36.0	40.0	50.0	50.0	....	....	....

[1]For thicknesses or lengths intermediate between those listed, available dimensions are in proportion within the limits of the manufacturing equipment, and will be quoted on request.

[2]The dimensions shown are subject to the following limitations:

(a) The sizes shown apply to plate in the as rolled temper.

(b) In the soft (O), quarter-hard (¼H), and half-hard (½H) tempers, the maximum limiting lengths are:
36 feet for widths up to 100 inches,
24 feet for widths greater than 100 inches to maximum width shown in the table.

(c) The maximum limiting size of plate in any alloy in the soft temper (O) is 118″×30′.

(d) Plate can be supplied in the following tempers:

Thickness 3 inches to 2 inches	As rolled, soft (O).
Thickness less than 2 inches to 1 inch	As rolled, soft (O), quarter-hard (¼H).
Thickness less than 1 inch to ¼ inch	As rolled, soft (O), quarter-hard (¼H), half-hard (½H).

(e) Flatness. Same as Note [2], paragraph (d), under Table 51.

(f) Shearing. Unless otherwise specified, plates in all commercial widths in thicknesses up to 1 inch are sheared.
Minimum sheared widths are as follows:

Thickness in inches	Minimum sheared width in inches
0.250 to 0.375	6
0.376 to 1.000	8 for lengths up to 10 feet 18 for lengths greater than 10 feet

Thicker plate or narrower widths must be sawed.

TABLE 51—MAXIMUM COMMERCIAL[1] SIZES OF HEAT-TREATABLE ALLOY PLATE[2]

17S AND 53S ALLOYS

Thickness Inches	Maximum width Inches	Maximum length for maximum width		Maximum length in feet for indicated widths						
		Inches	Feet	Widths 43 inches or less	Width 60 inches	Width 72 inches	Width 84 inches	Width 96 inches	Width 108 inches	Width 120 inches
3	60	60	5.0	7.1	5.0	....	....	....	....	....
2¾	63	63	5.2	7.7	5.5	....	....	....	....	....
2½	66	66	5.5	8.5	6.0	....	....	....	....	....
2¼	70	70	5.8	9.5	6.8	....	....	....	....	....
2	74	74	6.2	10.6	7.6	6.3	....	....	....	....
1¾	79	79	6.6	12.1	8.7	7.3	....	....	....	....
1½	86	86	7.2	14.2	10.1	8.4	7.2	....	....	....
1¼	94	94	7.8	17.0	12.2	10.3	8.8	....	....	....
1	105	105	8.8	20.3	14.5	12.0	10.2	9.5	....	....
⅞	112	112	9.3	24.6	17.6	14.6	12.5	10.9	9.7	....
¾	120	120	10.0	28.4	20.3	16.9	14.4	12.5	11.2	10.0
⅝	120	147	12.3	34.0	24.3	20.1	17.2	15.0	13.3	12.3
½	96	229	19.1	42.6	30.5	25.4	21.7	19.1	....	....
⅜	96	305	25.4	57.0	36.0	33.9	29.0	25.4	....	....
¼	90	432	36.0	50.0	36.0	36.0	36.0	....	....	....

[1]In some cases larger sizes can be produced by means of special manufacturing practices; requirements for larger sizes should be the subject of special inquiry. For thicknesses or lengths intermediate between those listed, available dimensions are in proportion within the limits of the manufacturing equipment, and will be quoted on request.

[2]The dimensions shown are subject to the following limitations:

(a) Lengths greater than 36 feet are not commercially available in any alloy in any heat-treated temper (W or T).

(b) For 53S-T the limiting maximum lengths are:
36 feet for widths up to 100 inches.
24 feet for widths greater than 100 inches to 120 inches.

(c) The maximum limiting size of plates in any alloy in the soft temper (O) is 118″×30′.

(d) Flatness. The degree of flatness which can be obtained depends on the alloy and temper and upon the dimensions of the plate:
The limiting maximum size for stretcher leveled plate is ⅞-inch thick by 90 inches wide in all commercial lengths.
Plate wider than 90 inches and/or thicker than ⅞ inch is supplied roller leveled.
Plate thicker than 1 inch is supplied as flat as can be produced on the rolling mills.

(e) Shearing. Unless otherwise specified, plates in all commercial widths in thicknesses up to ⅝ inch are sheared. Minimum sheared widths are as follows:

Thickness in inches	Minimum sheared width in inches
0.250 to 0.375	6
0.376 to 0.625	8 for lengths up to 10 feet 18 for lengths greater than 10 feet

Thicker plate or narrower widths must be sawed.

TABLE 52—RANGE OF COMMERCIAL SIZES OF ROUND TUBING

Thickness		Minimum O.D. Inches	Maximum O.D. in inches						
Stubs gage	Inches	3S, 17S, 53S	3S-O 53S-O	3S-¼H	3S-½H	3S-¾H	3S-H	53S-T	17S-T
..	0.500	2¾	7¼	9	7¾	5	3¾	9½	7¾
..	0.484	2¾	7 15/32	9 7/32	7 23/32	5¼	4	9 15/32	7 15/16
..	0.480	2½	7	7	7	5¼	4	7	8
..	0.468	2½	7¾	9½	8¼	5½	4	10	8¼
..	0.453	2½	7 31/32	9 15/32	8 7/32	5½	4¼	9 15/32	8½
..	0.450	1½	7	7	7	5½	4¼	7	8½
..	0.437	1½	8¼	10	8½	5½	4¼	10¾	8 13/16
..	0.421	1½	8 15/32	10 15/32	8 31/32	5½	4¼	11 5/32	9
..	0.406	1½	8¾	10¾	9	6	4½	11⅛	9
..	0.400	1½	7	7	7	6	4½	7	8⅞
..	0.390	1½	8 31/32	11 1/32	9 15/32	6	4½	11 1/32	8⅞
..	0.375	1⅜	10	11	10¼	6¼	4¾	11	8⅞
..	0.359	1⅜	9 31/32	10 29/32	10 15/32	6¼	5¼	10 29/32	8¾
..	0.350	1⅜	7	7	7	6½	5¼	7	8¾
..	0.344	1⅜	10	10⅞	10⅞	6½	5¼	10⅞	8¾
..	0.328	1⅜	10 15/32	10 25/32	10 25/32	7 7/32	5½	10 25/32	8 11/16
..	0.320	1	7	7	7	7	5½	7	8 11/16
..	0.312	1	10¾	10¾	10¾	7½	5½	10¾	8 11/16
1	0.300	⅞	7	7	7	7	6	7	8½
..	0.297	⅞	10 21/32	10 21/32	10 21/32	7 23/32	6	10 21/32	8½
2	0.284	⅞	7	7	7	7	6¼	7	8½
..	0.281	⅞	10⅝	10⅞	10⅞	8¼	6¼	10⅞	8½
..	0.266	⅞	10 17/32	10 25/32	10 25/32	8 23/32	6½	10 25/32	8⅜
3	0.259	¾	7	7	7	7	6¾	7	8⅜
..	0.250	¾	10¾	10¾	10¾	9¼	7	10¾	8⅜
4	0.238	⅝	7	7	7	7	7	7	8 3/16
..	0.234	⅝	10 21/32	10 21/32	10 21/32	9 15/32	7 15/32	10 21/32	8 3/16
5	0.220	⅝	7	7	7	7	7	7	8 3/16
..	0.218	⅝	10⅝	10⅝	10⅝	10⅜	8	10⅝	8 1/16
6	0.203	9/16	10 17/32	10 17/32	10 17/32	10 9/32	8 15/32	10 17/32	8 1/16
..	0.187	9/16	10½	10½	10½	10¼	9¼	10½	8 1/16
7	0.180	½	7	7	7	7	7	7	8 1/16
..	0.171	½	10 13/32	10 13/32	10 18/32	10⅜	9 31/32	10 13/32	8
8	0.165	7/16	7	7	7	7	7	7	8
..	0.156	7/16	10⅜	10⅜	10⅜	10⅜	10	10⅜	7 15/16
9	0.148	⅜	7	7	7	7	7	7	7 13/16
..	0.140	⅜	10 9/32	10 9/32	10 9/32	10 9/32	9 31/32	9 15/32	7 13/16
10	0.134	5/16	7	7	7	7	7	7	7 13/16
..	0.125	5/16	10¼	10¼	10¼	10¼	10¼	8¾	7 13/16
11	0.120	¼	7	7	7	7	7	7	7¾

TABLE 52—RANGE OF COMMERCIAL SIZES OF ROUND TUBING—Continued

Thickness		Minimum O.D. Inches	Maximum O.D. in inches						
Stubs gage	Inches	3S, 17S, 53S	3S-O 53S-O	3S-¼H	3S-½H	3S-¾H	3S-H	53S-T	17S-T
12	0.109	¼	9 15/32	9 15/32	9 15/32	9 15/32	9 15/32	8 23/32	7¾
13	0.095	¼	7	7	7	7	7	7	7¾
..	0.093	¼	9¼	9¼	9¼	9¼	9¼	8¼	7¾
14	0.083	3/16	7	7	7	7	7	7	7 11/16
..	0.078	3/16	8 31/32	8 31/32	8 31/32	9	9	7 23/32	7⅝
15	0.072	3/16	7	7	7	7	7	6¾	7⅝
16	0.065	3/16	7	7	7	7	7	6¾	7 9/16
..	0.062	3/16	9	9	9	9	9	6¾	7 9/16
17	0.058	3/16	7	7	7	7	7	6¼	6¼
18	0.049	⅛	7	7	7	7	7	5	5
..	0.046	⅛	8 31/32	8 31/32	8 31/32	8 31/32	8 31/32	3¾	3¾
19	0.042	⅛	6¾	6¾	6¾	6¾	6¾	3¾	3¾
20	0.035	⅛	5	5	5	5	5	3¼	3¼
21	0.032	⅛	4	4	4	4	4	2¾	2¾
22	0.028	⅛	4	4	4	4	4	2¾	2¾
23	0.025	⅛	3½	3½	3½	3½	3½	2½	2½
24	0.022	⅛	3	3	3	3	3	2	2
25	0.020	⅛	2¾	2¾	2¾	2¾	2¾	1⅜	1⅜
26	0.018	⅛	2½	2½	2½	2½	2½	9/16	9/16
27	0.016	⅛	1¼	1¼	1¼	1¼	1¼	7/16	7/16
28	0.014	⅛	1	1	1	1	1	⅜	⅜
29	0.013	⅛	1	1	1	1	1	5/16	5/16
30	0.012	⅛	⅝	⅝	⅝	⅝	⅝	¼	¼
31	0.010	⅛	9/16	9/16	9/16	9/16	9/16	3/16	3/16

TABLE 53—RANGE OF COMMERCIAL SIZES OF ROD AND BAR

3S, 17S, 52S, AND 53S ALLOYS

Commodity	Smallest	Largest
	Diameter Inches	Diameter Inches
Round rod (cold finished)	3/8	1 1/2
Round rod (rolled)	1 9/16	8
	Distance across flats Inches	Distance across flats Inches
Square bar (cold finished)	3/8 x 3/8	1 1/2 x 1 1/2
Square bar (rolled)	1 x 1	4 x 4
Hexagonal bar (cold finished)	3/8	1 1/2
Hexagonal bar (rolled)	1 9/16	2
Octagonal bar (cold finished)	3/8	1 3/16
	Dimensions Inches	Dimensions Inches
Square edge rectangular bar, common alloy (cold finished)	1/16 x 3/8	1 1/2 x 4
Square edge rectangular bar, strong alloy (cold finished)	1/16 x 3/8	†
Square edge rectangular bar (rolled)	3/32 x 1 1/8	3 x 7
Round edge rectangular bar (rolled)	1/8 x 5/8	1/2 x 6

†Widths up to 3.0 inches, provided cross-sectional area is not greater than 3 square inches.
The above table indicates the range of commercial sizes. Intermediate sizes are not all available.

TABLE 54—APPROXIMATE TEMPERS OF ROLLED BAR, ROD, AND SHAPES

3S AND 52S[1] ALLOYS

Shape	Diameter or least distance across flats in inches	Approximate temper[2]	
		Rolled	Cold finished
Rounds, Squares, Hexagons, Octagons	Up to ¾″ inclusive	½H	½H to ¾H
	Greater than ¾″ to 1½″	¼H to ½H	½H to ¾H
	Greater than 1½″ to 3″	¼H	¼H to ½H
	Greater than 3″ to 8″	⅛H to ¼H	⅛H to ¼H
Rectangles	Up to ⅛″ inclusive	¼H to ½H	½H to ¾H
	Greater than ⅛″ to ½″	¼H to ½H	½H
	Greater than ½″ to 1½″	¼H	¼H
	Greater than 1½″ to 3″	⅛H to ¼H	⅛H to ¼H
Structural shapes	Standard sizes	¼H to ½H	....

[1]52S is not produced in shapes.

[2]Tempers shown are *approximate.* Minimum tensile strengths are not guaranteed, but experience indicates that the tempers shown for various commodities may normally be expected. The small sizes tend to run harder than the large sizes, since they finish colder from the rolls; also, cold finishing introduces a greater percentage of reduction in cross-sectional area, hence more strain hardening. *Typical* or *average* properties (*not minimum*) for the various alloys in the various tempers are shown in Table 3, page 23.

CONVERSION TABLES

AND OTHER

USEFUL DATA

USEFUL CONVERSION FACTORS

One board foot	$=144$	cubic inches
One centimeter	$=0.3937$	inches
One centimeter	$=0.01$	meters
One centimeter	$=10$	millimeters
One cubic centimeter	$=3.531 \times 10^{-5}$	cubic feet
One cubic centimeter	$=0.06102$	cubic inches
One cubic foot	$=28317$	cubic centimeters
One cubic foot	$=1728$	cubic inches
One cubic foot	$=7.481$	gallons
One cubic foot	$=28.32$	liters
One cubic inch	$=16.39$	cubic centimeters
One degree (angle)	$=0.01745$	radians
One foot per second	$=0.6818$	miles per hour
One gallon	$=231$	cubic inches
One gallon	$=3.785$	liters
One gram	$=2.205 \times 10^{-3}$	pounds
One gram per cu. cm.	$=62.43$	pounds per cubic foot
One horse-power	$=550$	foot-pounds per second
One horse-power	$=0.7457$	kilowatts
One inch	$=2.540$	centimeters
One kilogram	$=1000$	grams
One kilogram	$=2.205$	pounds
One kg. per sq. mm.	$=1422$	pounds per square inch
One mile	$=5280$	feet
One pound	$=453.6$	grams
One lb. per sq. in.	$=0.068$	atmospheres
One lb. per sq. in.	$=2.307$	feet of water
One lb. per sq. in.	$=2.036$	inches of mercury
One lb. per sq. in.	$=7.031 \times 10^{-4}$	kg. per sq. mm.
One radian	$=57.30$	degrees
One square inch	$=6.452$	square centimeters
One ton (long)	$=2240$	pounds
One ton (long) per sq. in.	$=1.575$	kg. per sq. mm.

TABLE 55—FRACTIONS TO DECIMALS

Fractions					Decimals	Fractions					Decimals
				1/64	.015625					33/64	.515625
			1/32		.03125				17/32		.53125
				3/64	.046875					35/64	.546875
		1/16			.0625			9/16			.5625
				5/64	.078125					37/64	.578125
			3/32		.09375				19/32		.59375
				7/64	.109375					39/64	.609375
	1/8				.125		5/8				.625
				9/64	.140625					41/64	.640625
			5/32		.15625				21/32		.65625
				11/64	.171875					43/64	.671875
		3/16			.1875			11/16			.6875
				13/64	.203125					45/64	.703125
			7/32		.21875				23/32		.71875
				15/64	.234375					47/64	.734375
1/4					.25	3/4					.75
				17/64	.265625					49/64	.765625
			9/32		.28125				25/32		.78125
				19/64	.296875					51/64	.796875
		5/16			.3125			13/16			.8125
				21/64	.328125					53/64	.828125
			11/32		.34375				27/32		.84375
				23/64	.359375					55/64	.859375
	3/8				.375		7/8				.875
				25/64	.390625					57/64	.890625
			13/32		.40625				29/32		.90625
				27/64	.421875					59/64	.921875
		7/16			.4375			15/16			.9375
				29/64	.453125					61/64	.953125
			15/32		.46875				31/32		.96875
				31/64	.484375					63/64	.984375
1/2					.5	1					1.0

TABLE 56—INCHES TO CENTIMETERS

One Foot = 30.480 Centimeters

	0	1	2	3	4	5	6	7	8	9	10	11
0	0	2.540	5.080	7.620	10.160	12.700	15.240	17.780	20.320	22.860	25.400	27.940
1/32	0.079	2.619	5.159	7.699	10.239	12.779	15.319	17.859	20.399	22.939	25.479	28.019
1/16	0.159	2.699	5.239	7.779	10.319	12.859	15.399	17.939	20.479	23.019	25.559	28.099
3/32	0.238	2.778	5.318	7.858	10.398	12.938	15.478	18.018	20.558	23.098	25.638	28.178
1/8	0.318	2.858	5.398	7.938	10.478	13.018	15.558	18.098	20.638	23.178	25.718	28.258
5/32	0.397	2.937	5.477	8.017	10.557	13.097	15.637	18.177	20.717	23.257	25.797	28.337
3/16	0.476	3.016	5.556	8.096	10.636	13.176	15.716	18.256	20.796	23.336	25.876	28.416
7/32	0.556	3.096	5.636	8.176	10.716	13.256	15.796	18.336	20.876	23.416	25.956	28.496
1/4	0.635	3.175	5.715	8.255	10.795	13.335	15.875	18.415	20.955	23.495	26.035	28.575
9/32	0.714	3.254	5.794	8.334	10.874	13.414	15.954	18.494	21.034	23.574	26.114	28.654
5/16	0.794	3.334	5.874	8.414	10.954	13.494	16.034	18.574	21.114	23.654	26.194	28.734
11/32	0.873	3.413	5.953	8.493	11.033	13.573	16.113	18.653	21.193	23.733	26.273	28.813
3/8	0.953	3.493	6.033	8.573	11.113	13.653	16.193	18.733	21.273	23.813	26.353	28.893
13/32	1.032	3.572	6.112	8.652	11.192	13.732	16.272	18.812	21.352	23.892	26.432	28.972
7/16	1.111	3.651	6.191	8.731	11.271	13.811	16.351	18.891	21.431	23.971	26.511	29.051
15/32	1.191	3.731	6.271	8.811	11 351	13.891	16.431	18.971	21.511	24.051	26.591	29.131
1/2	1.270	3.810	6.350	8.890	11.430	13.970	16.510	19.050	21.590	24.130	26.670	29.210
17/32	1.349	3.889	6.429	8.969	11.509	14.049	16.589	19.129	21.669	24.209	26.749	29.289
9/16	1.429	3.969	6.509	9.049	11.589	14.129	16.669	19.209	21.749	24.289	26.829	29.369
19/32	1.508	4.048	6.588	9.128	11.668	14.208	16.748	19.288	21.828	24.368	26.908	29.448
5/8	1.588	4.128	6.668	9.208	11.748	14.288	16.828	19.368	21.908	24.448	26.988	29.528
21/32	1.667	4.207	6.747	9.287	11.827	14.367	16.907	19.447	21.987	24.527	27.067	29.607
11/16	1.746	4.286	6.826	9.366	11.906	14.446	16.986	19.526	22.066	24.606	27.146	29.686
23/32	1.826	4.366	6.906	9.446	11.986	14.526	17.066	19.606	22.146	24.686	27.226	29.766
3/4	1.905	4.445	6.985	9.525	12.065	14.605	17.145	19.685	22.225	24.765	27.305	29.845
25/32	1.984	4.524	7.064	9.604	12.144	14.684	17.224	19.764	22.304	24.844	27.384	29.924
13/16	2.064	4.604	7.144	9.684	12.224	14.764	17.304	19.844	22.384	24.924	27.464	30.004
27/32	2.143	4.683	7.223	9.763	12.303	14.843	17.383	19.923	22.463	25.003	27.543	30.083
7/8	2.223	4.763	7.303	9.843	12.383	14.923	17.463	20.003	22.543	25.083	27.623	30.163
29/32	2.302	4.842	7.382	9.922	12.462	15.002	17.542	20.082	22.622	25.162	27.702	30.242
15/16	2.381	4.921	7.461	10.001	12.541	15.081	17.621	20.161	22.701	25.241	27.781	30.321
31/32	2.461	5.001	7.541	10.081	12.621	15.161	17.701	20.241	22.781	25.321	27.861	30.401

TABLE 57—INCHES TO DECIMALS OF A FOOT

	0	1	2	3	4	5	6	7	8	9	10	11
0	0	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167
1/16	.0052	.0885	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219
1/8	.0104	.0938	.1771	.2604	.3438	.4271	.5104	.5938	.6771	.7604	.8438	.9271
3/16	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323
1/4	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375
5/16	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427
3/8	.0313	.1146	.1979	.2813	.3646	.4479	.5313	.6146	.6979	.7813	.8646	.9479
7/16	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531
1/2	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583
9/16	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	.8802	.9635
5/8	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688
11/16	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740
3/4	.0625	.1458	.2292	.3125	.3958	.4792	.5625	.6458	.7292	.8125	.8958	.9792
13/16	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844
7/8	.0729	.1563	.2396	.3229	.4063	.4896	.5729	.6563	.7396	.8229	.9063	.9896
15/16	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948

TABLE 58—SHEET AND TUBE GAGES

Gage number	Thickness in inches		Gage number	Thickness in inches		Gage number	Thickness in inches	
	(B & S gage) Sheet	(Stubs gage) Tubing		(B & S gage) Sheet	(Stubs gage) Tubing		(B & S gage) Sheet	(Stubs gage) Tubing
00	0.365	0.380	11	0.091	0.120	23	0.023	0.025
0	0.325	0.340	12	0.081	0.109	24	0.020	0.022
1	0.289	0.300	13	0.072	0.095	25	0.018	0.020
2	0.258	0.284	14	0.064	0.083	26	0.016	0.018
3	0.229	0.259	15	0.057	0.072	27	0.014	0.016
4	0.204	0.238	16	0.051	0.065	28	0.013	0.014
5	0.182	0.220	17	0.045	0.058	29	0.011	0.013
6	0.162	0.203	18	0.040	0.049	30	0.010	0.012
7	0.144	0.180	19	0.036	0.042	31	0.009	0.010
8	0.128	0.165	20	0.032	0.035	32	0.008	0.009
9	0.114	0.148	21	0.028	0.032	33	0.007	0.008
10	0.102	0.134	22	0.025	0.028	34	0.006	0.007

TABLE 59—TYPICAL PROPERTIES OF VARIOUS COMMON MATERIALS

Material	Weight Lb./cu. ft.	Tensile Strength Lb./sq. in.	Yield Point Lb./sq. in.	Elongation PerCent in 2 Inches	Shear Strength Lb./sq. in.	Modulus of Elasticity Lb./sq. in.	Poisson's Ratio	Coefficient of Expansion per degree F. 68°-212°	Specific heat Calories per gram	Thermal Conductivity[1] 100° C.	Electrical Conductivity[2] 20 C.
Aluminum (commercially pure)	See Tables 3 and 4 for values for various alloys.					10,300,000	0.33	0.0000133	0.23	0.52	58
Brass: 34% Zn hard sheet	521	76,000	......	7	......	15,000,000	0.33	0.000011	0.086	0.20	25
34% Zn annealed sheet	521	46,000	......	64	......	15,000,000	0.33	0.000011	0.086	0.20	25
40% Zn, sand cast	521	46,000	22,000	15	......	13,000,000	0.36	0.000010	0.086	0.20	25
Bronze: 8% Sn, .03%-.25% P hard sheet	548	90,000	......	..	......	17,000,000	0.33	0.000010	0.086	0.18	23
8% Sn, .03%-.25% P annealed sheet	548	50,000	25,000	25	......	17,000,000	0.33	0.000010	0.086	....	23
10.5% Sn, 0.5% P—cast	...	31,000	......	8	......	17,000,000	0.33	0.000010	0.086	....	23
Copper (pure): hard sheet	557	60,000	24,000	8	24,000	17,500,000	0.33	0.000009	0.101	0.92	..
annealed	557	40,000	10,000	45	10,000	17,500,000	0.33	0.000009	0.101	0.92	97
Iron: gray cast	450	21,000	......	..	......	12,000,000	0.25	0.000006	0.115	0.10	..
wrought plate	480	48,000	27,000	25	40,000	25,000,000	0.28	0.000006	0.115	0.14	17
Lead: chemical, cast	710	2,800	......	50	......	2,600,000	0.43	0.000017	0.034	0.08	8
rolled	710	3,300	......	..	......	....	....	....	0.034	0.08	8
Monel metal: hard sheet	550	100,000	90,000	8	87,000	25,000,000	0.39	0.000008	0.128	0.06	4
hot-rolled plate or cast	550	70,000	30,000	30	46,000	25,000,000	0.39	0.000008	0.128	0.06	4
Steel: carbon cast, annealed	490	75,000	41,000	24	60,000	29,000,000	0.30	0.000007	0.118	0.12	15
structural	490	65,000	33,000	22	48,000	29,000,000	0.30	0.000007	0.118	0.12	15
5% Ni, 0.3% C	490	95,000	65,000	28	......	28,000,000	0.30	....	.....	0.12	..
Wood: oak	45	8,000	......	..	1,300	1,300,000	....	0.000003	0.33	0.00035	..
spruce	27	5,500	......	..	780	1,200,000	....	0.000003	0.33	0.00030	..
yellow pine	27	5,000	......	..	700	1,000,000	....	....	0.33	0.00030	..
Zinc: die cast	440	30,000	......	2	......	12,000,000	0.11	0.000018	0.092	0.27	30
cold rolled	440	30,000	......	30	19,000	12,000,000	0.11	0.000018	0.092	0.27	30

[1]Calories transmitted per second through a plate one centimeter thick per square centimeter of its surface when the difference of temperature between the two faces of the plate is one degree centigrade.
[2]Volume conductivity in per cent based on 100 for copper (Annealed Copper Standard).

INDEX

WARRANTY CLAUSE

The products of Aluminum Company of America are supplied under the standard warranty clause which appears on its acknowledgment of orders:

"The goods sold hereunder are warranted to be free from defects in material and workmanship and this express warranty is in lieu of and excludes all other warranties expressed or implied by operation of law or otherwise. Defective material may be returned to us after inspection by us and upon receipt of definite shipping instructions from us. Goods so returned will be replaced or repaired without charge, but we shall not be liable for loss, damage or expense directly or indirectly arising from the use of the material or from any other cause, our liability being expressly limited to the replacement or repair of defective material. Every claim on account of defective material or workmanship or for any other cause shall be deemed waived by you unless made in writing within sixty (60) days from the date of the receipt of goods to which such claim relates."

PUBLICATIONS

• *Architecture*	Contemporary Spandrel Design Windows of Alcoa Aluminum Window Sills and Copings of Alcoa Aluminum
• *Brewery*	Alcoa Aluminum, Its Use in the Brewery
• *Chemical*	Aluminum in the Chemical Industry
• *Dairy*	Alcoa Aluminum—The Modern Money-Saving Metal Bears the Seal of Dairy Approval
• *Electrical Conductors*	Aluminum Bus Bars A.C.S.R. Rural Lines A.C.S.R. 220,000 Volt Transmission Lines in the United States and Canada Electrical Characteristics of A.C.S.R.
• *General*	Alcoa Aluminum and Its Alloys
• *Metal Working*	Finishes for Aluminum Machining Aluminum Riveting Aluminum Welding Aluminum
• *Paint*	Aluminum Paint Manual, including Specifications
• *Truck Bodies*	Alcoa Aluminum for Truck Bodies Alcoa Aluminum for Truck Body Construction
• *Non-Aluminum Products*	Activated Alumina

These books are free and available upon request to the nearest sales office of Aluminum Company of America.

PRODUCTS

• *Ingots*

Ingots, billets, and slabs for wrought aluminum products.

Casting alloy ingot.

Metallurgical granulated ingot.

* * *

• *Materials for Fabrication*

Rolled structural shapes: Angles, beams, channels, car channels, and zees.

Extruded shapes and moldings for aircraft, architecture, railroad rolling stock, truck bodies, bus bodies, etc.

Rod and Bar: Round, rectangular, hexagonal, and special shapes for screw machine stock, etc.

Plate: Sheared and sawed, rectangular, circles, and tread.

Tank plates.

Tread plate.

Sheet: Alclad, flat, coiled, corrugated, circles, reflector sheet, and roofing sheet.

Handrails and fittings.

Pipe and fittings (I. P. S.).

Tubing: Round, square, streamline, and special shapes.

Castings: Sand, die, and permanent mold.

Forgings.

Pressings.

Impact extrusion products.

Draw press products.

Screw machine products.

Rivets.

Bolts.

Nuts.

Nails.

Screws: Machine and wood.

Wire: Round, half round, oval, half oval, and flattened.

Welding flux and wire.

* * *

• *Specialties*

Barrels and shipping containers.

Chemical and special apparatus.

Kettles.

Tanks: Welded and riveted.

Job-shop products.

* * *

• *Automotive Products*

Lynite pistons and connecting rods.

Lynite Lo-Ex pistons.

* * *

• *Electrical Conductors and Accessories*

Electrical cable: All-aluminum and A. C S. R. (Aluminum cable steel reinforced).

Cable fittings and accessories.

Rigid conduit.

Bus bars: Flat, tubular, and rolled channel.

Bus bar fittings and accessories.

Fuse wire.

Magnet wire.

* * *

• *Powder and Paste*

Powder: For paint pigment, printing ink, lithographic ink, rubber compounding, dusting, etc.

Paste for paint pigment.

* * *

• *Packaging Products*

Bottle closures and bottle sealing machines.

Collapsible tubes.

Foil: Plain, printed, embossed, lacquered, and paper-mounted.

* * *

• *Nonmetallic Products*

Activated alumina.

Aluminum fluoride.

Aluminum hydrate.

Aluminum oxide.

Fluorides: Sodium and miscellaneous.

Fluorspar.

Lime: Quick and hydrated.

Plaster: Calcined.

SALES OFFICES

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RULED SHEETS

FOR NOTES AND

DIAGRAMS

208 ALUMINUM COMPANY OF AMERICA

210 ALUMINUM COMPANY OF AMERICA

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